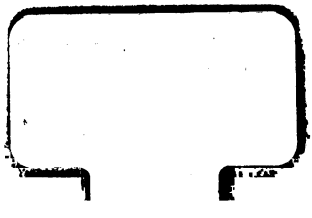

COLLECTED PAPERS
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OF

CHARLES R. EASTMAN

Bulletin of the Museum of Comparative Zoology
AT HARVARD COLLEGE
VOL. XXXI. NO.

ON THE RELATIONS OF CERTAIN PLATES IN THE DINICHTHYIDS,

WITH DESCRIPTIONS OF NEW SPECIES.

BY C. R. EASTMAN.

WITH FIVE PLATES.

CAMBRIDGE, MASS., U. S. A.:
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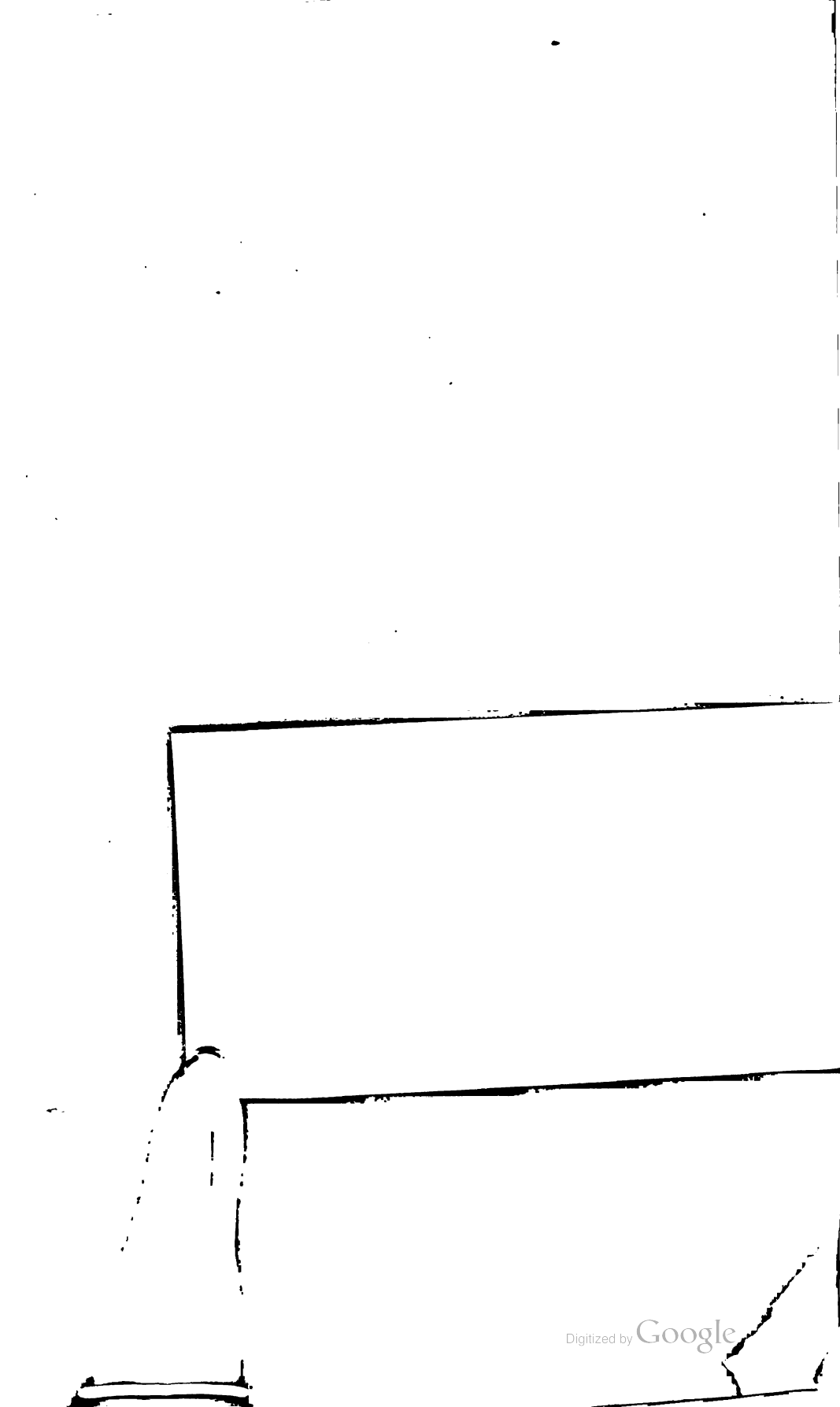

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No. 2. — *On the Relations of Certain Plates in the Dinichthyids, with Descriptions of New Species.* By C. R. EASTMAN.

THE present contribution may be regarded as a continuation and enlargement of two previous articles on the Dinichthyids,[1] one of which discussed the relationships of certain detached and little known plates, and the other endeavored to trace the ancestry of the group. Some of the plates mentioned in the first paper are now illustrated and more fully described, together with others which afford additional evidence regarding the osteology of *Dinichthys;* and the views set forth in the second paper are now considered more in detail. In addition, descriptions are offered of several new species, and restorations are given of the dorsal and ventral aspects of *Dinichthys.*

Unless otherwise stated, the material upon which all of the following descriptions are based is preserved in the Museum of Comparative Zoölogy at Cambridge, Mass. To Mr. Alexander Agassiz, Director of the Museum, the most cordial and grateful thanks of the writer are due for the opportunity to study the collection, and to publish the results herein set forth.

Dorsal Plates. — It is proposed to consider first the system of plates covering the dorsal surface of the body in *Dinichthys.* These plates are shown in their natural arrangement, as known to exist in *D. intermedius* and *D. terrelli*, in Plate 1, Fig. 1; their correspondence with homologous elements in *Coccosteus* and related genera will be obvious from an inspection of the diagrams. The restoration here given may seem to call for a word of explanation, since it differs in certain respects from the familiar ones of Newberry and others.[2] The cranial osteology is based upon one of the most perfect heads of *Dinichthys intermedius* ever discovered, now the property of the Cambridge Museum. A full description of the

[1] Amer. Journ. Science, [4], Vol. II. pp. 46–50, July, 1896. Proc. Amer. Assoc. Adv. Science, Buffalo Meeting, August, 1896 (Abstract in Amer. Geol., Vol. XVIII. pp. 222, 223).

[2] Newberry, J. S., Palæozoic Fishes of North America (Monograph U. S. Geol. Survey, Vol. XVI. Plate LII. Fig. 2), 1889. Dean, B., Fishes, Living and Fossil, 1895, p. 134, Fig. 134.

same specimen has already been published by E. W. Claypole.[1] Inasmuch as this cranium lacks the marginal and suborbital plates, these have been supplied in the diagram from Newberry's restoration. The fact that they are shown more in projection than perspective imparts a wider and more flattened appearance to the cranium than is strictly natural; the dorso-laterals are likewise drawn as if flattened out, instead of conforming to the curvature of the body. The outline of the dorso-median has been reduced to scale from a photograph of an exceptionally perfect plate obtained from Dr. William Clark by the British Museum; its exact position as regards the dorso-laterals has been ascertained from specimens in the Museum of Comparative Zoölogy. Hence the restoration can be considered as such only in the sense that the parts are now brought together in their completeness and proper relationships, and are shown on the same scale.

The earlier restorations already referred to are subject to the following criticisms. First, the anterior portion of the dorso-median is produced in imagination so as to cover the exposed space behind the occipital region; secondly, the conditions of overlap and underlap are represented on only one side of the antero-dorso-lateral, instead of on three sides; thirdly, the postero-dorso-lateral is not shown at all.

Hitherto the postero-dorso-lateral has never been found in direct association with other plates, and its position has accordingly remained in doubt. It has long been known under Newberry's designation of "post-clavicular," and is a plate of not uncommon occurrence in the detached condition. Its triangular form, the markings impressed upon it by overlying plates, and the course of the sensory canal system across it, appeared to the writer[2] sufficient evidence for assigning the plate theoretically to the position indicated in the diagram; and it is therefore interesting to record the discovery of a specimen which establishes the entire correctness of this inference. The new specimen represents the right antero- and postero-dorso-lateral plates of *D. terrelli*, firmly articulated together, as shown in Plate 2, Fig. 1. It is from the Cleveland Shale, and was found in the vicinity of Lindale, Ohio, by Mr. Prentis Clark. The inner surface of the plates is alone visible, the external side being embedded in the matrix. The mode of articulation between the two plates is by pegs and sockets, the position of which is fairly constant among the specimens that have been observed. The lar-

[1] Claypole, E. W., The Head of Dinichthys (Amer. Geol., Vol. X. p. 199), October, 1892.

[2] Amer. Journ. Science, [4], Vol. II. p. 48, July, 1896.

gest and most perfect plate that the writer has seen is preserved in the Museum of Comparative Zoölogy, and measures 65 cm. in length (Catalogue No. 1325). The corresponding element in *D. intermedius* is hardly to be distinguished except for its smaller size. An excellent example of the latter species belonging to the School of Mines Cabinet of Columbia University shows the postero-dorso-laterals of either side of the body commingled with other plates pertaining to the same individual; it is valuable for furnishing comparative measurements of the different bones, and deserves further study.

The orientation of the plate in question may be readily determined, either by an inspection of the overlapped area, or by noting the course of the sensory canals. These arise at the anterior border, where they meet the single straight furrow that traverses the antero-dorsal-lateral; and from this point they sweep inwardly, sometimes as a single and sometimes as a double channel, as far as about the middle of the exposed portion of the plate, where they cease. In this respect the genus differs from *Coccosteus*, which has the canals continued on to, and in some cases entirely across, the dorso-median. The insunken area formed by the overlap of the latter plate stands in marked contrast to the irregular depressions produced by the overlap of the antero-dorso-lateral. The graceful curve forming the postero-lateral boundary of the dorso-median is projected upon the underlying plate, and shallow depressions are left where the transverse ridge on the under surface of the dorso-median rested on the subjacent plate. This ridge, it should be noted, occupies the same relative position as its homologue in *Coccosteus*.

The upper boundary of the lateral plates is indicated by a deeply insunken area on the antero-dorso-lateral, and a slight indentation on the free margin of the postero-dorso-lateral. Below, these as yet undiscovered plates must have been connected with the ventral armoring, either directly, or more probably through the intervention of the "claviculars." The curvature of the ascending arm of the latter furnishes us at the same time with the curvature of the missing laterals, and we can also form an approximate estimate of their height and length. It is to be hoped that the laterals may yet be identified as such, when the entire dermal covering of *Dinichthys* can be compared plate for plate with its European congeners.

Ventral Plates. — Grave difficulties have been encountered in the attempt to reconstruct the ventral armor of *Dinichthys*, owing to the detached condition in which the plates have invariably been found. It is perhaps but natural that the views which were originally entertained

regarding the structure of the plastron should have received important modifications in consequence of later discoveries. Thus, Newberry's supposed posterior ventrals were afterwards identified as the suborbitals, and his so called "jugulars" have since been demonstrated by Wright [1] to be in reality the posterior ventrals.

The restorations of Wright and Dean [2] (the latter being somewhat modified after Wright's figures) leave the median plate or plates unaccounted for, and it remained for Dean in a subsequent publication [3] to reconstruct the ventral covering afresh, with the addition of a single element along the median line. But as pointed out by the present writer in a review of Dean's article,[4] the evidence is not entirely conclusive that a distinct antero-median ventral was not present in advance of the posterior element and overlying it, although now obscured on the specimen by weathering. The writer has since had an opportunity for examining the original, which is referred by Dr. Dean with some hesitation to *Dinichthys gouldi*. Although it is badly fractured precisely at the spot where we should expect a suture to exist, and therefore incapable of affording positive proof on this point, nevertheless the fact that the two plates we know were at least potentially present should have retained their normal position with respect to each other, while the adjacent plates have become displaced, points strongly toward a union of some kind between them.

For an undoubted example of fusion of the mid-ventrals we must turn to the specimen of *Dinichthys terrelli* figured by Newberry on Chart VI. (Figure A), accompanying the second volume of the Ohio Geological Survey Report. The original is still preserved in the School of Mines Cabinet, and has been recently refigured by Dr. Dean.[5] The resemblance of the anterior and posterior portions to plates presently to be described, and occurring as distinct elements, is sufficiently obvious. In this specimen, and the statement doubtless applies to all adult individuals of the same species, fusion exists between the mid-ventrals; in *D. gouldi* fusion probably likewise exists. These two instances are sufficient, in Dr. Dean's estimation, to compel us "to accept the thesis that the median ventral

[1] Wright, A. A., The Ventral Armor of Dinichthys (Amer. Geol., Vol. XIV. pp. 313–320), 1894. Report Ohio Geol. Survey, Vol. VII. pp. 620–626, 1893.

[2] Dean, B., Fishes, Living and Fossil, 1895, Fig. 135, p. 134.

[3] Dean, B., The Ventral Armoring of Dinichthys, etc. (Trans. N. Y. Acad. Sci., Vol. XV. pp. 157–163, May, 1896).

[4] Amer. Geol., Vol. XVIII. pp. 316, 317, 1896.

[5] Dean, B., Trans. N. Y. Acad. Sci., Vol. XVI. Plate III., 1897.

plates of *Dinichthys* must be separate or fused in *all* members of the genus."

Under ordinary circumstances, such an interpretation would appear most logical, since we should expect, *a priori*, marked differences in the mode of union of the mid-ventrals to be indicative of different genera. We might reasonably infer that these differences were accompanied by variations in the dentition and other parts of the body, although this is a point which could only be determined empirically. Should it be ascertained, however, that forms existed having a like dentition, a like configuration and arrangement of plates as in *Dinichthys*, yet differing among themselves as respects the mode in which the median ventrals were united, there would be difficulty in estimating the value of this latter character. Ought it to be regarded as a valid generic distinction, or, other things being equal, merely as an adaptive variation affecting different species indiscriminately? From present indications it would appear highly probable that diverse conditions existed in the ventral plates of forms which agree in their remaining characters, so far as known, with *Dinichthys*. It must be noted, also, that amongst the species of this genus the paired ventral plates are exceedingly variable in their characters, more so in fact than any other plates of the body. Not only do they vary in form, relative proportions, and mode of union among different species, but there are considerable differences to be observed within one and the same species; one class of variations within specific limits will be referred to later under the head of ventro-lateral plates.

To sum up these difficulties briefly, we must admit on the one hand that theoretical considerations are opposed to the view that species of one and the same genus should differ widely as respects the number and arrangement of the median ventrals; but on the other hand, evidence is wanting to show that the forms they represent differed in any respects further than this from *Dinichthys*. And until positive evidence is forthcoming, such as finding the plates naturally associated with the dentition, it is impracticable to employ characters of the ventral plates as a test of generic rank. In our opinion, both prudence and convenience dictate that plates which resemble the known elements of *Dinichthys*, when found in the detached condition, are to be referred to that genus until criteria are at hand for determining them otherwise. Accordingly, certain isolated plates, whose description follows, will be referred to *Dinichthys* by virtue of their obvious affinities with that genus. And it will be assumed, provisionally at least, that in this genus the median

ventrals may exist in three different conditions of union; they may simply overlap, as in *Coccosteus;* they may be fused into a single elongated piece; or they may be interlocked with one another. Examples of these three modes of union will now be considered.[1]

Interlocking Median Ventrals. — Two instances have been recorded where the median ventral plates of *Dinichthys* are articulated with one another; the first was made known by E. W. Claypole in 1893,[2] the second by the present writer in 1896.[3] In both cases the plates occurred in the detached condition, and were referred provisionally to the genus *Titanichthys.* Further investigation has since shown this to have been an erroneous determination, and the only genus that they can be certainly referred to in the present state of our knowledge is *Dinichthys.* The original of Professor Claypole's figure is preserved in the Museum of the Ohio State University at Columbus. It is a very large and heavy postero-ventro-median, and with it were associated the greater part of the postero-ventro-laterals. The proportions indicate a considerably larger species than either *D. terrelli* or *D. hertzeri,* and accordingly the name *D. ingens*[4] has been suggested for it by A. A. Wright. As a detailed description of these remains is in course of preparation by Professor Wright, it is sufficient for our purpose merely to cite this as an illustration of a particular mode of union between the median ventrals.

The other example of articulation or dovetailing is furnished by a specimen in the Museum of Comparative Zoölogy, now figured for the first time (Plate **2**, Fig. 2). It is broadly lozenge-shaped, and its diagonals measure 20 by 31 cm. The resemblance of this plate to the posterior part of the single element in *D. terrelli,* already referred to, as figured by Newberry and Dean, is obvious. Its size, thickness, and markings impressed upon it by the paired ventrals, are also in substantial agreement. In these particulars it is seen to be closely allied to *D. terrelli;* but on the other hand the articulation with the antero-ventro-median is precisely the same as in *D. ingens.* The plate in question was collected by Mr. Terrell, in the Cleveland Shale of Lorain County, Ohio; but whether

[1] See abstract of a preliminary paper by A. A. Wright, entitled, "New Evidence upon the Structure of Dinichthys" (5th Ann. Rep. Ohio State Acad. Sci., 1897, pp. 59, 60).

[2] Report Geol. Survey of Ohio, Vol. VII. p. 611, Plate XL. Fig. 1.

[3] Amer. Journ. Science, [4], Vol. II. p. 47.

[4] Should an identity be established between these plates and the mandible described by Claypole as *D. kepleri,* the latter name is entitled to priority.

associated or not with other remains cannot now be ascertained. Theoretical considerations are certainly opposed to the idea that this plate pertained to either *D. terrelli* or *D. ingens;* and we are compelled to regard it as indicating an as yet unknown Dinichthyid species.

Fused Median Ventrals. — Under this head must be placed the two examples already referred to, that have been described by Newberry[1] and Dean.[2] The originals are preserved in the School of Mines Cabinet at Columbia University, and have been determined as *D. terrelli* and *D.* (?) *gouldi.* Whether fusion took place as a strictly adaptive character in forms having a thin plastron, whether it occurred only in adult individuals, or whether it characterized all the individuals belonging to particular species, are questions for future discoveries to determine. That fusion did not exist in all species of *Dinichthys* appears, however, extremely probable.

Overlapping Median Ventrals. — Species which have the postero-ventro-median overlapped by the anterior element represent the normal or primitive condition, as exemplified by the genus *Coccosteus.* Three specimens of the detached antero-ventro-median and two of the postero-ventro-median are preserved in the Cambridge collection, whose relations to contiguous plates were plainly those of overlap and underlap. The bone shown in Plate 2, Figs. 5, 6, exhibits such a striking resemblance to its homologue in *D. terrelli,* that there can be no doubt as to its identity. It is evident that the plate under discussion is entire, since its margins taper gradually to a thin edge, and show no signs of having been broken away from a lower portion. Hence, the only important difference that is to be observed between this specimen and *D. terrelli* relates to the mode of union with the posterior element; in the present case it overlaps, in *D. terrelli* it is fused with the hinder piece. As we know of no other species to which it can be referred, we must include it, provisionally at least, under the last named species.

The special characters of this plate have been described elsewhere, although at that time the specimen was supposed to belong to *Titanichthys.* It may be remarked in passing that the semicircular flange forming the anterior margin (seen best on the ventral aspect) is continuous with similar compressed borders on the antero-ventro-laterals. None of these margins reveal any trace of plates overlapping them in

[1] Report Geol. Survey of Ohio, Vol. II. Part. II. (Palæontology), pp. 10, 31, and Chart VI. Fig. A.

[2] Trans. N. Y. Acad. Science, Vol. XV. pp. 157–163, 1896; Ibid., Vol. XVI. pp. 57–60, 1897.

front; so that an interlateral element, such as is present in *Coccosteus*, cannot be said to exist. We are therefore limited to assigning a strictly lateral (external) position for the so called "claviculars" or coracoids.

A second specimen of the ventro-median preserved in the Cambridge collection (Catalogue No. 1299) shows the longitudinal ridge on the visceral surface more strongly developed than the first, and is both thicker and wider towards its posterior extremity.

There is yet a third specimen, which is smaller and of somewhat different configuration from the preceding; this is shown in Plate 3, Fig. 1. The visceral surface is embedded in the matrix, so that its character cannot be made out. In form it is somewhat suggestive of the parasphenoid bone of *Ctenodus*, but its structure as seen under the lens proves it to be Dinichthyid. The plate was obtained by Dr. Clark in the Cleveland Shale, near Lindale, Ohio. Owing to its smaller size, it may be referred with some reservation to *D. intermedius*.

From the same locality as the preceding, Dr. Clark has also obtained two unique plates, one of which is preserved in counterpart, and is shown in Plate 5, Fig. 1. Lanceolate in outline, and perfectly symmetrical, it presents a very graceful appearance; its length is 29 cm., and its maximum width 12.5 cm. Only the visceral aspect is exposed, and this is marked by two slightly oblique ridges, such as occur also in the corresponding position of *D. terrelli*. The plate is abruptly truncated in front, and bears indications of overlap by the antero-ventro-median. We shall find that additional light is thrown upon these relationships when we consider the plastron immediately to be described. The specimen is somewhat thinner than other ventral plates that have been noticed thus far, and it differs also in form. For the present, it must be regarded as representing an unknown Dinichthyid.

Overlapping Median Ventrals preserved in Situ.

So far, but two instances have been reported where the ventral plates were retained in their natural relations with respect to one another. The less perfect of these was described very briefly by von Koenen,[1] by whom it is doubtfully referred to *D. minor*. Only the left half of the plastron is preserved in this case; its entire length is assumed to have been about 16 cm., and its width 6 or 7 cm. The condition of the

[1] Koenen, A. von, Ueber einige Fischreste, etc. (Abhandl. Gesellsch. Wissen. Göttingen, Vol. XL. p. 18), 1895.

specimen is too imperfect to admit of a precise determination of the several elements, as the author has informed us by letter.

The only other instance recorded where the plastron has been preserved *in situ*, is that made known by the writer at the Buffalo Meeting of the American Association for the Advancement of Science. For the discovery of this interesting fossil, science is indebted to Mr. F. K. Mixer, Curator of the Buffalo Society of Natural Sciences, who found the slab in place at the bottom of a small stream bed near Sturgeon Point, on the lake shore, twenty miles west of Buffalo, N. Y. The horizon at this point is the black Portage Shale, which has already yielded a considerable number of fish remains.[1] The plates were correctly determined by Mr. Mixer to be of Dinichthyid nature, and were so labelled by him and placed on exhibition in the Museum of the Buffalo Society. To this enthusiastic collector the writer is greatly indebted for the privilege of studying the specimen, and of presenting the following description of it.

Although the fossil has suffered considerably from aqueous and atmospheric erosion, the salient features have been so far preserved as to furnish points of control sufficient for reconstructing almost the entire topography. The slight extent to which the diagram given in Plate 1 has been reconstructed may be seen from a comparison with a photograph of the actual fossil, reproduced in Plate 4. In most cases the sutural indications are so distinct, and continuous over such an area, that we have only to produce them in the same general direction across breaks in the surface until they meet, in order to complete the small portions that are interrupted. Thus, among the prominent landmarks that are left may be mentioned the terminal angles of the antero-ventro-laterals, which overlie the postero-ventro-laterals in their natural position. Half way between these points gives us the median line of the body; and as all the plates are arranged symmetrically with reference to it, it is clear that the fossil has been in no wise distorted. A knowledge of this fact permits us to supply the contours of one side from information derived from the other, and fortunately the two sides supplement each other to a remarkable degree. The only boundary lines that are not tolerably distinct are the forward portions of the antero-ventro-laterals. We will consider the relations of the different plates in order.

Ventro-Median Plates. — The first question that arises concerning the median ventrals is whether they are represented by one element or by

[1] Mixer, F. K., Amer. Geol., Vol. XVIII. p. 223, October, 1896. Williams, H. U., Bull. Buffalo Soc. Nat. Sci., Vol. V. pp. 81–84, 1886.

two? And if two, what is their mode of union? We have no hesitation in answering that two median plates are present, and that the anterior overlaps the posterior, as in *Coccosteus*. The evidence appears perfectly decisive, and is of twofold nature; it depends upon a prominent surface elevation over the very region where we should expect the boundary between two median ventrals to be, and upon the fact that two centres of ossification are discernible.

The surface elevation referred to is palpably of the same nature as those prominences which are formed by the hinder extremities of the antero-ventro-laterals where they are superimposed upon the posterior pair of ventro-laterals. All of these elevations are more or less eroded in the specimen, but the one under consideration is scarcely more so than the others. If it were a purely fortuitous bulge of the surface, we should expect similar ones to occur elsewhere, whereas the prevailing aspect of the plates is flat and smooth. But inasmuch as the only remaining elevations are found at those places where we know for certain that boundaries occur, and as this occurs at the only place in the median line where we should expect to find a boundary, we are compelled to look upon this as a significant, not an accidental feature. Moreover, the shape of the elevation corresponds with the tapering extremity of the antero-ventro-median, superimposed upon the posterior element; and the outline of the latter is seen to be perfectly normal as compared with homologous plates, when we cut it off at this point. In fact, it is noteworthy that the shape of the postero-ventro-median bears a marked similarity to the bone last described (*supra*, p. 26), and shown in Plate 5, Fig. 1.

But still more pertinent evidence as to the existence of two median ventrals is furnished by the structure of the plates themselves. It is apparent at a glance that in the postero-ventro-median ossification proceeded from a single centre, which was nearly coincident with the centre of the plate itself. On holding the slab so as to reflect light at a proper angle, the course of vascular (Haversian) canals can be seen very distinctly, especially at the right anterior boundary; and all of these radiate toward the centre of the plate. Vascular canals are likewise apparent on the antero-ventro-laterals, but are only faintly perceptible on the antero-ventro-median. If the latter plate were articulated or fused with the posterior element, as in *D. terrelli*, it would be difficult to account for the significant elevation already referred to; and considering the relative thinness of the plates, such a mode of union could hardly have proved advantageous. It is more natural to suppose that the connection

among all plates of the ventral armoring was one of simple overlap, as in *Ceccosteus* and other forms.

Ventro-Lateral Plates. — The inner margins of the antero-ventro-laterals are traceable with certainty throughout the greater portion of their length, but with a lesser degree of probability for the remaining (anterior) portion, where they are not only much abraded, but in part covered over by extraneous fragments, as will be noted presently. The boundaries of these plates are more sinuous than in any other known species, and their proportions with respect to the posterior pair are also different. But, as already remarked, the ventrals exhibit a greater range of variation, even within specific limits, than all the other plates of the body.

One class of variations that deserves notice here is the relative length of the two sets of ventro-laterals. Sometimes the anterior pair is the longer, and again, apparently within the limits of the same species, the posterior pair exceeds them in length.

Possibly these differences may have been correlated with sex, a greater portion of the abdomen having been protected in the one case than in the other;[1] but however this may be, we are obliged to recognize the existence of these two patterns or varieties of the plastron. The present specimen, therefore, belongs to that type of plastron which has the anterior ventro-laterals longer than the posterior.

The external margin of the postero-ventro-laterals appears to have been evenly rounded. Unfortunately, the central portion of the plates has been eroded away, so that the contour of the inner margins can only be postulated. It is probable, however, owing to the tenuity of these plates, that the condition of their union was one of simple overlap; hence Dean's figures of *D. gouldi* (?) have been followed in restoring their inner boundaries. Of the anterior borders of these plates, no trace whatever remains. There may be some significance attached to the fact that the antero-ventro-laterals are symmetrically worn away, their present eroded margins forming a regular curve from the ventro-median outward. Whether this symmetrical wearing away was in any respect influenced by the anterior margins of the hinder pair of plates may perhaps be questioned; but at all events we must conclude that the former anterior boundary of these plates was not far from, and was probably parallel with, the interrupted edges of the antero-ventro-laterals. That the plates in question were separated for a considerable distance posteriorly, is witnessed by an impression of the visceral surface of the

[1] Amer. Geol., Vol. XVIII. p. 317.

ventro-median, which is preserved as far as its posterior apex on the slab.

We have now to determine what species of *Dinichthys* is represented by the ventral armor just described. In the absence of the dentition, we must either associate the remains theoretically with mandibles of corresponding size that occur in the same horizon, or must regard the plastron as belonging to a new species. Fortunately, the proportions between the different body plates are well known in *D. terrelli* and *D. intermedius*, and from them we can readily compute the length of mandible and size of dorsal shield to which the present specimen would correspond. Thus, the ratio between the length of mandible and length of the antero-ventro-laterals in *D. terrelli*[1] is 1.14, and, assuming that about the same proportion held true for the species now under discussion, we should attribute it with a mandible 24 or 25 cm. long. Now, from the Genesee Shales near Bristol Center, New York, J. M. Clarke has described under the title of *D. newberryi* a mandible measuring 28⅓ cm. in length.[2] In the same horizon are also found detached dorsal shields which are considered by this writer as belonging to *D. newberryi*, although their dimensions correspond almost precisely with those of *D. minor*. In fact, Dr. Clarke's tables (pp. 22, 23) show that, while the mandibles of *D. newberryi* are about one half as large as in *D. hertzeri* and *D. terrelli*, the dorsal shields are less than one fifth the size of those in either species. Such a marked discrepancy of ratio appears incredible in the light of comparison with other species; and the measurements of the plastron now under discussion militate with the assumption that they, the mandibles of *D. newberryi*, and the dorsal shields from the same horizon as the last, all belonged to a single species. The correspondence of parts is such as to permit of a theoretical association of the plastron with the mandibles of *D. newberryi*, but not with the dorsal shields that are referred by Dr. Clarke to this species; these latter being more properly assignable to *D. minor*, or a species of equal size with *D. minor*.

It must be borne in mind, however, that these conclusions depend entirely upon empirical formulas; they are therefore more or less tentative and provisional. It may be presumed from the general nature of things, and in the absence of any contrary evidence, that the proportions existing between parts of the derm skeleton were fairly constant within the limits of one and the same genus. But the correspondence

[1] Wright, A. A., Report Geol. Surv. Ohio, Vol. VII. p. 626.
[2] Clarke, J. M., Bull. U. S. Geol. Survey, No. 16, p. 17, 1885.

of parts as known in *Dinichthys* does not hold true by any means for other genera (*Trachosteus*, *Mylostoma*, etc.) belonging to the same family; and this fact admonishes us not to press hypothetical correlations too far, even within specific limits. Caution is enjoined in this particular case by yet another consideration. From the same locality and formation, Mr. Mixer has obtained a pair of mandibles associated with fragmentary Dinichthyid plates. The condition of these remains does not warrant a precise specific determination, but their affinities are probably with *D. minor*. The length of each ramus is about 17 cm., and the maximum height 5 cm. Either, therefore, these remains and the plastron represent together but a single species (*D.? minor*), or we have evidence of two medium-sized species (*D.? minor* and *D.? newberryi*) in the Portage Shale.

Under these circumstances it is apparent that a positive identification of the species is impossible. For the sake of convenience, we might follow Dr. Clarke's example, and refer all the detached plates occurring in the Genesee Shales to *D. newberryi*, and all those from Portage Shale to *D. minor*. But there is no reason for supposing that each of these horizons contains but a solitary species; the indications point rather to the presence of more than one species in both horizons. And there is no reason why the doctrine of correlation of parts should not be applied to all the species of *Dinichthys* until experience has shown it to be invalid for some of them. Provisionally, therefore, we are in favor of referring the Portage plastron to the species with which it most closely agrees in measurement and geological horizon, that is to say, with *D. newberryi*. On the other hand, the Portage mandibles that have just been mentioned, and the detached dorso-median plates from the Genesee, may be referred provisionally to *D. minor*.

Comparative measurements of certain derm-plates for several species of *Dinichthys* are exhibited by the table on the following page.

Besides the plastron just described, there are several other interesting structures preserved on the same slab. In advance of the plastron are a number of badly weathered fragments, which evidently represent the dorsal plates of the body. The forward portions of both antero-ventro-laterals are covered over, and their proper boundaries obscured, by some of these fragments; but none of them are identifiable with certainty unless it be the antero-lateral tip of the dorso-median, which rests upon the angle of the right antero-ventro-lateral. This concealment of the underlying plates along their margins is unfortunate, since the restored anterior boundary has not such a clear basis of fact as one could wish

Comparative Measurements of Dinichthys Species.

No.	Species.	I. Length of Mandible.	II. Length of DM.	III. Length of DM without carinal process.	IV. Width of DM.	V. Length of A. V. L.	VI. Length of P. V. L.	VII. Length of Plastron.	VIII. Ratio between Columns II. and VII.
1	*D. ingens* . . .	. . .	. .	. .	. .	. .	76+		
2	" *hertzeri* . . .	59.0	67.5	. .	53.0				
3	" *terrelli* . . .	56.25	65.0	36.0	57.5				
4	" " . . .	36.88	48.26	33.02	43.18	40.91	40.64	69.85	1.45
5	" " . . .	. . .	. .	. .	. .	48.26	55.88	90.17	1.87
6	" *newberryi* . .	28.33							
7	Portage plastron	. . .	. .	. .	. .	20.0	17.0	30+	
8	*D. gouldi* . . .	17–20	. .	. .	. .	. .	12.6	8+	
9	" *intermedius* .	22.86	41.91	29.21	26.67	17.15	22.86	35.56	0.85
10	" *minor* . . .	10+	20.32	12.2	13.15	. .	. .	. .	1.59
11	Detached DM of Genesee Shale	. . .	. .	12.5	13.75				

for. At the same time it must be remembered that the front margin of the plastron in all species of *Dinichthys* conforms to a peculiar and well marked type.

To the right of the left antero-ventro-lateral is a small cleaver-shaped plate (7.5 cm. long by 3 cm. wide), the like of which is unknown among the derm plates of Coccosteids. It certainly does not belong to the dental apparatus, and is excluded from the orbital region on account of its size. There can be no doubt that the plate is entire, or nearly so; but we must confess ignorance as to its position on the body. Just behind the unidentified plate is to be seen a small portion of the vertebral axis, very imperfectly preserved, together with supports for the dorsal fin. The form of the neural arches is shown with some distinctness, as well as their articulation with the proximal row of basal cartilages. The outer tips of the distal row of basals appear to have been bluntly terminated, or even swollen.

Descriptions of New Species.

Under this heading are included, besides species altogether new to science, certain others which are now demonstrated for the first time to belong to the genus *Dinichthys*. The subject may be properly introduced by a consideration of the latter forms first.

As is well known, a large number of genera and species of Arthrodires have been founded on detached fragments, which commonly yield but little insight into the structure of the fish as a whole. Sometimes our knowledge of these forms is increased by the discovery of more perfect specimens, or by finding parts in natural association with the dentition or with other parts. The dentition obviously yields the most trenchant characters that can be employed for the discrimination of species; but in *Dinichthys* scarcely less important characters are furnished by the dorso-median plate. Owing to the massiveness of this plate, it is not readily subject to fracture or distortion, and is perhaps of more frequent occurrence than any other plate in the body. Its configuration varies markedly amongst the different species of *Dinichthys*, but remains fairly uniform within the limits of one and the same species; hence its systematic importance is very great.

There is one feature about the dorso-median which appears to be peculiar to the Dinichthyids; or, to put it differently, the Dinichthyids are distinguished from remaining Coccosteids by the possession of a certain characteristic structure; and this is the large, excavated carinal process by which the dorsal shield is terminated posteriorly. (See Plate 2, Figs. 3, 4; Plate 3, Figs. 2, 3.) All of the *Coccosteidæ*, so far as known, have a median longitudinal keel or ridge on the inferior surface of the dorso-median; but it is developed to a different degree, and is terminated in a different manner, amongst the several genera. In *Coccosteus* it ends posteriorly in a simple blunt spine; in *Homosteus* the ridge is stronger, and terminates in a knob at the posterior border of the shield; and in *Heterosteus* the keel is greatly developed, but is not produced behind the margin to any great extent, nor is it excavated superiorly. This series of Coccosteid genera leads up to the conditions that exist in the Dinichthyid group, where the inferior ridge is terminated posteriorly by a distinct process, such as is unknown in other members of the family. If we arrange the Dinichthyid forms in order of relative development of the carinal process, we shall have the following series: *Coccosteus* sp. Pander (hereinafter described as *D. livoni-*

cus); a form from the Eifel Devonian, described below as *D. pelmensis*; *Pelecyphorus* Trautschold; *Asterolepis bohemica* Barrande (hereinafter described as *D. bohemicus*); *Dinichthys;* and lastly, the genus *Titanichthys*, which is so closely allied to *Dinichthys* as to pass for a mutation or modification of the same. *Titanichthys* is, essentially, a huge *Dinichthys* with lighter bones and a degenerate dentition. It is presumable that when the osteology of *Brontichthys*, *Gorgonichthys*, *Mylostoma*, *Trachosteus*, and related genera, shall have become known as fully as in *Dinichthys*, their affinities with one another will be found to be much closer than with the more primitive Coccosteids. Newberry was inclined to regard these forms as constituting a distinct family, the *Dinichthyidæ;* but that would rather overreach the mark. We venture to adopt the middle course, and assign to the forms enumerated above the rank of a subfamily, known as the *Dinichthyinæ*.

As already remarked, we may regard the presence of a carinal process as sufficient ground for referring detached dorso-median plates to the *Dinichthyinæ*, instead of the *Coccosteidæ* in general. For precise generic determination, a knowledge of the dentition is of course necessary; but where we are in ignorance of the dentition, we may conveniently place all species founded upon such dorsal shields, for the time being at least, under the single genus *Dinichthys*. Precedent for this is already furnished by *D. precursor*, *D. ringuebergi*, *D. tuberculatus*, and the plates from the Genesee Shale referred to above as *D.* (?) *minor*. To this category may now be added the following new species: *D. livonicus*, *D. trautscholdi*, *D. pelmensis*, and *D. pustulosus*.

Dinichthys livonicus nomen nov.

1857. *Coccosteus* aus Livland, C. H. Pander, Ueber die Placodermen des devonischen Systems, p. 70, Plate B, Fig. 4.

1889. *Coccosteus*, H. Trautschold, Ueber Coccosteus megalopteryx, etc. (Zeitschr. deutsch. geol. Gesellsch., Vol. XLI. p. 38).

1896. *Dinichthys livonicus*, C. R. Eastman, Observations on the Dorsal Shields in the Dinichthyids (Amer. Geol., Vol. XVIII. p. 222).

The original of Pander's Plate B, Fig. 4, of his Placodermen des devonischen Systems, may be taken as the type of this species, and there may be presumably associated with it the specimen referred to by A. S. Woodward (Brit. Mus. Cat. No. P. 4731), in his Catalogue of Fossil Fishes, Vol. II. p. 293. Without doubt this represents one of the smallest and most primitive species of *Dinichthys*, yet its marked development of the carinal process in proportion to its size is sufficient reason for excluding it from *Coccosteus*. It apparently

has much in common with the type of dorso-median described by Trautschold as *Pelecyphorus*, but may best be considered as representing a distinct species.

Formation and Locality. — Devonian; Livonia and Government of St. Petersburg.

Dinichthys trautscholdi nomen nov.

1889. *Coccosteus megalopteryx*, H. Trautschold, Ueber Coccosteus megalopteryx, etc. (Zeitschr. deutsch. geol. Gesellsch., Vol. XLI. pp. 38–45, Plate V. Figs. 1–6.)
1890. *Coccosteus megalopteryx*, O. Jaekel (Neues Jahrb., Vol. II. p. 145).
1890. *Pelecyphorus*, H. Trautschold (Zeitschr. deutsch. geol. Gesellsch., Vol. XLII. p. 576).
1891. *Pelecyphorus*, G. Gürich, Ueber Placodermen und andere Fischreste im Breslauer mineralogischen Museum (Zeitschr. deutsch. geol. Gesellsch., Vol. XLIII. p. 906).
1896. *Dinichthys trautscholdi*, C. R. Eastman, Observations on the Dorsal Shields in the Dinichthyids (Amer. Geol., Vol. XVIII. p. 222).

The type specimens represented in Plate V. Figs. 1–6 of Trautschold's paper on *Coccosteus megalopteryx* (*loc. cit.*, 1889), are now preserved in the Breslau Museum. They are from the Devonian of the River Sjass, in Northwest Russia, and are apparently very closely related to the foregoing species. The principal differences consist in the larger size and less strongly arched condition of the dorso-median proper, and the different shape and position of the carinal process. The latter is more deeply excavated on its posterior face, stands nearly at right angles with the surface of the shield proper, and is given off from it slightly in advance of the hinder margin of the same. In this last respect we find a resemblance to the dorso-median described by Newberry as *D. precursor;* and, as in most American species, the process bears distinct traces on its inferior surface of the attachment of muscles (Trautschold, *loc. cit.*, Plate V. Fig. 6). On the other hand, *Coccosteus*-like affinities are shown by the tuberculated surface of the dorso-median, and by the presence upon it of sensory canals. These curve around toward one another posteriorly, but are not continued across the middle of the shield. The development of the inferior ridge and its terminal process is very pronounced. The dimensions of the largest process observed by Trautschold are stated to be 6.5 cm. in height by 3 cm. in width at the base, — proportions which are eminently Dinichthyid.

This species, which it seems proper to name in honor of its original describer, Professor Trautschold, was confused by this author with a Selachian ichthyodorulite which he mistook for a swimming appendage of *Coccosteus*. Later, when it was pointed out that *Coccosteus* could not properly include either of these forms, a new generic title was proposed for each, — *Megalopterix* for the ichthyodorulite (afterwards discovered to be identical with *Psammosteus*), and *Pelecyphorus* for the dorsal shields. Curiously enough, the

species were left unnamed in both cases, except that provision was made for calling them both *Megalopterix securigera* in the event of their being proved to represent but a single species of one and the same genus. The generic title *Pelecyphorus* is preocupied.

Formation and Locality. — Devonian; River Ssjass, Government of St. Petersburg.

Dinichthys pelmensis sp. nov.

Plate 2, Fig. 4.

The type of this species is represented by a specimen in the Schultze Collection belonging to the Museum of Comparative Zoölogy (Cat. No. 1375). It is from the Middle Devonian of Pelm, in the Eifel.

The greater portion of the left side of the dorso-median is preserved entire, but on the right side there remains only an impression of the under surface of the bone. The carinal process is admirably preserved, and is of large size in proportion to the dorsal shield proper. It is deeply hollowed out posteriorly, and stands less nearly perpendicular to the surface of the shield than in the two preceding species. The height of the process is 1.2 cm., and its maximum breadth 0.5 cm. The shield proper is 5.0 cm. long, and rather less than 4.5 cm. broad anteriorly. It is slightly arched transversely, and appears to have been emarginate in front. The sensory canals are distinctly traceable as far as the bone is preserved. That on the left side is seen to begin at a point about half way between the antero-posterior extremities of the shield, whence it continues nearly parallel with the postero-lateral margin of the same, but stops short of the median line shortly in advance of the process. Only the bare termination of the canal belonging to the right side is preserved on the present specimen. The surface of the plate is covered with fine reticulating ridges, at the intersections of which traces of minute tubercles are discernible. The effect of weathering, however, has been to reduce these, so that to the unaided eye the surface appears to be finely granulated. The thickness of the plate does not exceed 2 mm. except in the vicinity of the median longitudinal ridge.

Formation and Locality. — Middle Devonian; Eifel District.

Dinichthys eifeliensis Kayser.

Plate 3, Fig. 3; Plate 5, Fig. 4.

1880. *Dinichthys eifeliensis*, E. Kayser, Zeitschr. deutsch. geol. Gesellsch., Vol. XXXII. p. 817.

1895. *Dinichthys eifeliensis*, A. von Koenen, Ueber Fischreste des norddeutschen und böhmischen Devons (Abhandl. Ges. Wissensch. Göttingen, Vol. XL. pp. 16–18, Plate IV. Figs. 4, 5; Plate V. Fig. 1).

The mandibles of this species are estimated by von Koenen to have measured upwards of 50 cm. in length, and as it is the only Dinichthyid previously known with certainty from this locality, we may safely refer to it the speci-

mens figured in the accompanying plates. That shown in Plate **3**, Fig. 3, represents without doubt the carinal process of a large dorsal shield, such as could well have belonged to a species as large as *D. eifeliensis*. Two or three additional specimens of the process, and several detached plates that are referable to the same species, also form a part of the Schultze Collection. One of these, identifiable as the right antero-ventro-lateral, is shown in Plate **5**, Fig. 4.

Formation and Locality. — Middle Devonian; Gerolstein, Berndorf, and elsewhere in the Eifel District.

Dinichthys bohemicus (Barrande).

Plate 2, Fig. 3; Plate 5, Fig. 2.

1872. *Asterolepis bohemica*, J. Barrande, Système Silurien de la Bohême, Vol. I. Suppl., p. 637, Plate XXIX. Figs. 9–13.

1880. *Asterolepis bohemica*, A. von Koenen, Abhandl. Ges. Wissensch. Göttingen, Vol. XXX. p. 4.

1895. *Anomalichthys bohemicus*, A. von Koenen, Abhandl. Ges. Wissensch. Göttingen, Vol. XL. pp. 8, 21.

There can be no difficulty in recognizing the form commonly known as *Asterolepis bohemica* Barr., since fossil fishes are not numerous in the Devonian of Bohemia, and this one is distinguished by its peculiar ornamentation. The tubercles are rather closely set, conical, and their summits, instead of being smooth, are finely punctate. The plates are of relatively large size, and usually exhibit considerable convexity.

There are two specimens of the dorso-median preserved in the Schary Collection, now the property of the Museum of Comparative Zoölogy, besides the impression of a third plate supposed to be one of the ventro-laterals. They are all from the same horizon, and two are from the identical locality as Barrande's type specimens. As has already been pointed out by von Koenen (*loc. cit.*, 1895, p. 8), it is extremely improbable that the figures given by Barrande are of the dorso-median. Their lack of bilateral symmetry, and their relative thinness, compel us to locate them elsewhere, perhaps on the ventral surface.

Certain it is, however, that the specimens shown in the accompanying figures represent the median dorsal plate. Not only do they fulfil the requisite conditions of shape, symmetry, and thickness, but both of them present fractures on the posterior end, where the carinal process has been broken off, leaving a cross-section of the inferior longitudinal ridge. On the strength of this evidence we are obliged to assign the species to *Dinichthys*. One of the plates has the inferior ridge much more strongly developed than the other, and differs considerably in form. But the ornamentation is essentially the same, and we are content to refer them both to *D. bohemicus*, since the coinage of new specific titles to include uncharacteristic fragments is

greatly to be deprecated. Barrande's *Coccosteus fritschi*, as von Koenen has already surmised, is probably founded on the dorso-median of *Aspidichthys*.

Formation and Locality. — Middle Devonian (Étage Gg¹); Bohemia.

Dinichthys tuberculatus Newb.

1888. *Dinichthys tuberculatus*, J. S. Newberry, On the Fossil Fishes of the Erie Shale of Ohio (Trans. N. Y. Acad. Sci., Vol. VII. p. 179).

1889. *Dinichthys tuberculatus*, J. S. Newberry, Palæozoic Fishes of North America (Monogr. U. S. Geol. Surv., Vol. XVI. pp. 98, 99, Pl. XXXII. Fig. 3).

1889. *Dinichthys pustulosus* (*errore*), M. Lohest, De la découverte d'espèces américaines de poissons fossiles dans le Dévonien supérieur de Belgique (Bull. Soc. Géol. Belge, Vol. XVI. p. lvii).

1892. *Dinichthys pustulosus* (*errore*), [E. D. Cope], American Devonian Fishes found in Belgium (Amer. Naturalist, Vol. XXVI. p. 1025).

It is proper to record this species in connection with the foregoing, not only in order to complete the list of European representatives of the genus, so far as they have been described, but also because this is the only species of *Dinichthys* which is known to be common to both continents. This form may be regarded as the connecting link between the Old World species and the New; not that all the American Dinichthyids were derived from this species, but that this is one of the bonds through which the ancestry of the Western fishes can be traced backward to its starting point in Northern Europe. This chain of forms leads us eastward from Manitoba, through Iowa, Wisconsin, and Ohio, to New York and Pennsylvania; from the last named State *D. tuberculatus* carries us across the Atlantic to Belgium; next we meet with *D. eifeliensis* and *D. pelmensis* in Germany, followed by one species in Bohemia; and finally we come up with *D. trautscholdi* and *D. livonicus* associated with the ancestral *Coccosteus* and other derivatives from the same stock in the Devonian of Northwest Russia.

Formation and Locality. — Chemung Group; Pennsylvania. Psammite de Condroz; Belgium.

It remains only to present a description of certain Dinichthyid remains from the Hydraulic Limestone beds of Milwaukee, Wisconsin, a locality from which none have hitherto been known.

Dinichthys pustulosus sp. nov.

Plate 3, Fig. 4.

The F. H. Day Collection, purchased by the Museum of Comparative Zoölogy in 1881, contains a number of fish remains from the Hydraulic Cement Quarries near Milwaukee, Wisconsin. Among them are two plates whose preservation is such as to warrant description, especially since up to the present time but two species (*Rhynchodus greenei* and *Heteracanthus politus*) have been noticed from this locality.

The first of these (Plate 3, Fig. 4) is easily recognizable as the left antero-dorso-lateral of a new species of *Dinichthys*, and is chiefly remarkable for its finely tuberculated style of ornament. This plate is nearly twice the size of the corresponding element described by Newberry as *D. tuberculatus*, its articulating condyle is differently situated, and the tuberculation is entirely dissimilar. Of *D. tuberculatus*, Newberry[1] speaks as follows: "The tuberculation of the surface is relatively coarse, and the tubercles vary much in size and are irregularly scattered. Most of them seem to be hemispherical and plain, but others are more or less pitted, and a few are stellate." In the present species the tubercles are small and closely crowded, and are distinctly stellate at their bases.[2] It is somewhat surprising that there should be so few American species which present the characteristic surface ornamentation of the *Coccosteidæ;* the inference is that the tuberculated are more primitive than non-tuberculated forms.

A longitudinal fracture traverses the plate to the left of the sensory canal. It is interesting in that it displays very clearly the course of the vascular (Haversian) canals, which run essentially parallel with the surface of the plate. The canals are also well shown where the articulating condyle has broken off; and from their direction it would appear that the plate had grown by increments to the visceral surface only.

The second specimen in this collection that deserves notice is evidently the impression of one of the ventral plates, probably the left antero-ventro-lateral, the substance of the bone itself being entirely worn away. The surface ornament cannot be discovered from this specimen, but several fragments associated with it exhibit the same tuberculation as occurs on the antero-dorso-lateral just described. The only reason for disassociating the two specimens specifically is that they represent individuals of somewhat different size; but the disproportion does not appear of itself sufficient ground for separation. The supposed antero-ventro-lateral measures 23 cm. in length by 11 cm. in width at about the middle of the plate. How much of the anterior portion is wanting cannot be accurately determined. Another large specimen from the same locality is to be seen on exhibition in the United States National Museum, at Washington, D. C., bearing the catalogue number 14,821.

Fragments of various size, and indistinguishable from this species so far as one may judge from the ornamentation, have been collected by the writer in the State Quarry fish-bed, near North Liberty, Iowa.[3] Other remains have been found in the Cedar Valley Limestone of the same State by Professor Samuel Calvin. One of the largest of these, which belongs to the State Uni-

[1] Newberry, J. S., Palæozoic Fishes of North America (Monogr. U. S. Geol. Surv., Vol. XVI. p. 99), 1889.

[2] The artist has represented these somewhat diagrammatically in Figure 4, with the result of imparting a rougher aspect to the plate than is natural, although it is plain that the original has suffered somewhat from abrasion.

[3] See notes "On the Occurrence of Fossil Fishes in the Devonian of Iowa," appended to Report on the Geology of Johnson County (pp. 108–116), by Samuel Calvin, State Geologist. 1897.

versity Museum, shows the posterior portion of the cranium above and below very satisfactorily.

There is good reason for believing that this species also occurs in the Hamilton of New York State. Mr. F. K. Mixer, who has made a careful search for fish remains in the vicinity of Buffalo, has obtained certain fragments from the Encrinal Limestone near the mouth of Eighteen Mile Creek, which exhibit almost precisely the same style of ornamentation, and agree furthermore in size with *D. pustulosus*. One of these fragments is identifiable as the suborbital plate, and shows very distinctly the sensory canals. Another represents about one half of one of the ventro-lateral plates, is rabbeted upon the edges, and shows some variation in the size of its tubercles. Again we notice that tuberculation of the ventral plates bears witness to primitive conditions. The ventro-lateral measures 21 cm. in maximum width, and is traceable for about the same distance in a longitudinal direction, the remaining portion being broken away. It is to be hoped that further and better preserved material will be forthcoming from this horizon, since by reason of their greater antiquity and primitiveness Hamilton Dinichthyids are likely to prove even more interesting than those of Upper Devonian age. In the event of these plates being proved by future discoveries to belong to a species distinct from *D. pustulosus*, with which they are now provisionally associated, it is but fitting to reserve the name *D. mixeri* for the New York species, in honor of the gentlemen to whom we are indebted for our first knowledge of it.

The title of *D. pustulosus*, although misapplied by M. Lohest for *D. tuberculatus*, has never been defined, and we are accordingly at liberty to appropriate it for the present species.

Formation and Locality. — Hamilton Limestone; Wisconsin, Iowa, and New York (?).

In this connection a word may be said concerning another plate discovered by Mr. Mixer, near Sturgeon Point on the shore of Lake Erie. The fossil is embedded in a loose block derived apparently from the Portage Shale, exposures of which occur at this locality. It presents the inferior aspect of a small dorso-median plate, which is worn away anteriorly in such fashion as to reveal an impression of the external surface. This is seen to be finely tuberculated, and a few tubercles are left on an impression of a small plate (antero-dorso-lateral?) adjoining the first. The longitudinal carina and its terminal process are both indicated, although the latter is partly fractured. The plate is quite thin; and this fact, together with its small size, fine tuberculation, and other characters, renders it probable that it belonged to an immature individual. It may be referred with considerable certainty to *D. ringuebergi*, a species which until the present time has rested upon a solitary dorsal shield from the same locality. Mr. Mixer's specimen is about one fourth smaller than the type, however, and is of more slender construction. If properly regarded as a young individual, it is interesting as being one of the few that are known.

It is evident from the figures of the type specimen of *D. ringuebergi*[1] that the carinal process has been considerably eroded, and the diagram of the inferior surface is not wholly accurate. If the anterior margin is entire, as represented for this species, it covers the region back of the head almost as completely as in *Coccosteus*. The type specimen is preserved in the private collection of its first describer, Mr. E. N. S. Ringueberg, at Lockport, New York. All of the specimens discovered by Mr. Mixer that are mentioned in the present paper are preserved in the collection of the Buffalo Society of Natural Sciences.

Another very beautiful example of a young Dinichthyid is preserved in the Museum of Oberlin College, and through the courtesy of Professor A. A. Wright we have been enabled to reproduce a photograph of it, shown in Plate **5**, Fig. 3. It is only about 5 cm. long, and 4.5 cm. in maximum width; the external surface is non-tuberculated. Unfortunately the terminal process is missing, but the inferior carina is very distinct. It is also seen to be strongly emarginate in front.

The drawings for Plates **1** to **3** have been executed by Messrs. C. A. King and J. W. Folsom. Plates **4** and **5** are reproduced from photographs of the original specimens, taken by Dr. T. A. Jaggar, Jr., excepting Figure 3 of Plate **5**.

[1] Amer. Journ. Science, [3], Vol. XXVII. p. 477, June, 1884.

LIST OF AMERICAN SPECIES OF DINICHTHYS.

1.	*D. canadensis* Whiteaves,	Upper Devonian, Manitoba.
2.	*D. clarki* Claypole,	Cleveland Shale, Ohio.
3.	*D. corrugatus* Newberry,	Cleveland Shale, Ohio.
4.	*D. curtus* Newberry,	Cleveland Shale, Ohio.
5.	*D. gouldi* Newberry,	Cleveland Shale, Ohio.
6.	*D. gracilis* Claypole,	Cleveland Shale, Ohio.
7.	*D. hertzeri* Newberry,	Huron Shale, Ohio.
8.	*D. ingens* Wright (MS.),	Cleveland Shale, Ohio.
9.	*D. intermedius* Newberry,	Cleveland Shale, Ohio.
10.	*D. kepleri* Claypole,	Cleveland Shale, Ohio.
11.	*D. lincolni* Claypole,	Marcellus Shale, New York.
12.	*D. minor* Newberry,	Cleveland Shale, Ohio.
13.	*D. newberryi* Clarke,	Genesee and (?) Portage Shales, New York.
14.	*D. precursor* Newberry,	Corniferous Limestone, Ohio.
15.	*D. prentis-clarki* Claypole,	Cleveland Shale, Ohio.
16.	*D. ringuebergi* Newberry,	Portage Shale, New York.
17.	*D. terrelli* Newberry,	Cleveland Shale, Ohio.
18.	*D. tuberculatus* Newberry,	Chemung Group, Pennsylvania.
19.	*D. pustulosus* nobis,	Hamilton Limestone, Wisconsin, Iowa, and (?) New York.

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PLATE 1.

Fig. 1. *Dinichthys intermedius* Newb. × ⅛. Projection of cranium and dorsal plates in their natural relations with respect to one another. *DM*, Dorso-median; *ADL*, Antero-dorso-lateral; *PDL*, Postero-dorso-lateral. Sensory canals indicated by double dotted lines, boundaries of plates by single lines. The posterior process depends at an angle of about 60° from the plane of the dorso-median.

Fig. 2. *Dinichthys* (?) *newberryi* Clarke. × ⅛. Restoration of the Portage plastron shown in Plate 4. *AVM*, Antero-ventro-median; *PVM*, Postero-ventro-median; *AVL*, Antero-ventro-lateral; *PVL*, postero-ventro-lateral. Radiating lines show approximately the course of vascular canals. Overlapped borders of plates indicated by dotted lines.

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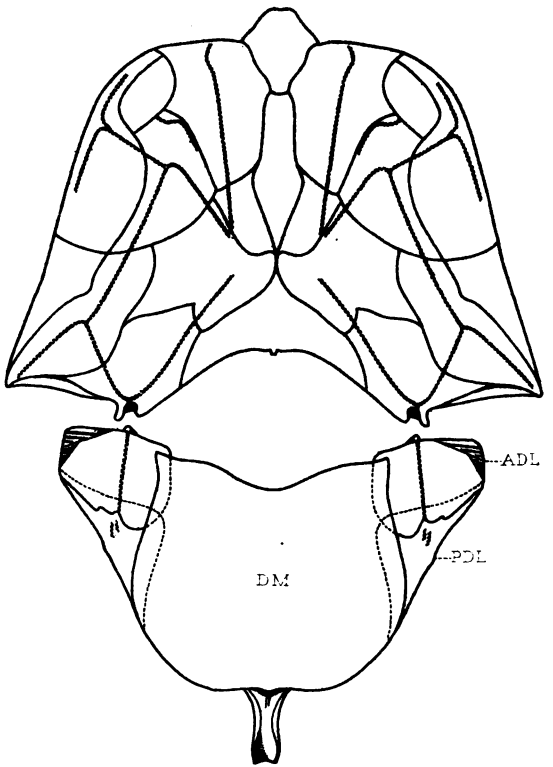

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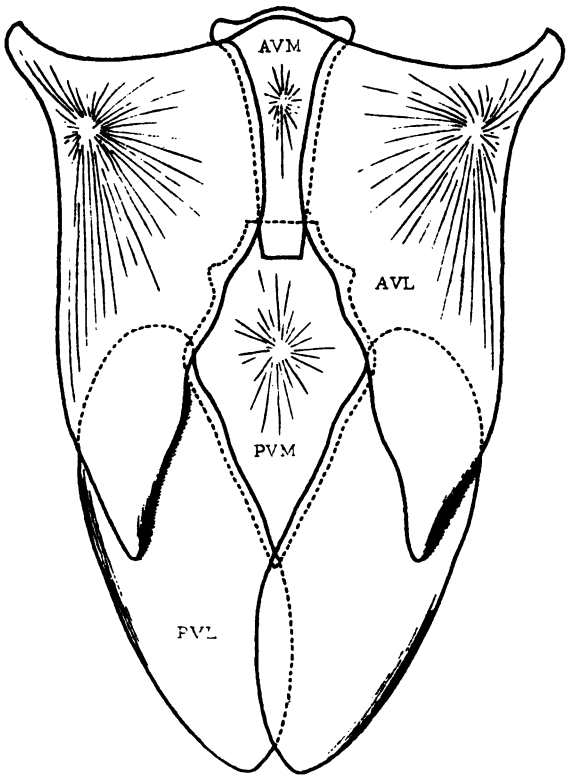

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PLATE 2.

Fig. 1. *Dinichthys terrelli* Newb. × ¼. Cleveland Shale; Lindale, Ohio. M. C. Z., Cat. No. 1379. Fragment showing internal surface of antero- and postero-dorso-lateral plates preserved in natural association with each other. Their union by pegs and sockets, the sinuous lateral boundary of the posterior plate, and the base of articulating condyle of the antero-dorso-lateral, are noteworthy features.

Fig. 2. Postero-ventro-median plate of an indetermined Dinichthyid species, from the Cleveland Shale of Lorain County, Ohio. × ⅛ (approximately). M. C. Z., Cat. No. 1300. The external surface, shown here, bears impressions of overlapping plates, and is notched in front for reception of the antero-ventro-median.

Fig. 3. *Dinichthys bohemicus* (Barr.). × ⅛. Middle Devonian (Étage Gg¹); Svagerka, Bohemia. M. C. Z., Cat. No. 1377. Tuberculated dorso-median plate. The posterior portion of the specimen, which was fractured obliquely downward, has been ground smooth and polished, so as to show the inferior carina in section.

Fig. 4. *Dinichthys pelmensis* sp. nov. × ¼. Middle Devonian; Pelm, Eifel District. M. C. Z., Cat. No. 1375. Dorso-median plate with perfectly preserved carinal process, and faint indications of sensory canals.

Fig. 5. *Dinichthys terrelli* Newb. × ⅛. Cleveland Shale; Lorain County, Ohio. M. C. Z., Cat. No. 1301. Antero-ventro-median plate, seen from the external surface. Thickness at posterior tip less than 2 mm.; the plate has every indication of being entire, or very nearly so.

Fig. 6. Same specimen as shown in Fig. 5, viewed from the internal or visceral side. The thickened T-shaped ridge seen on this surface is very characteristic.

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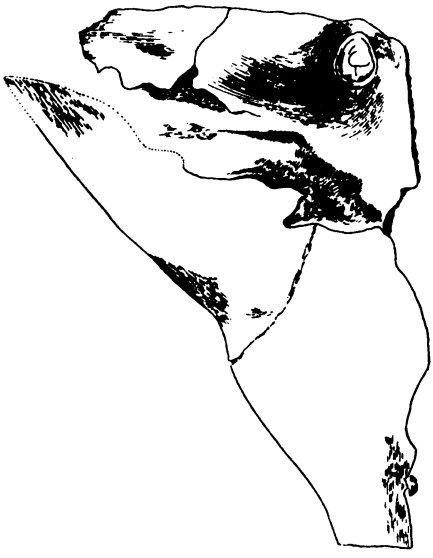

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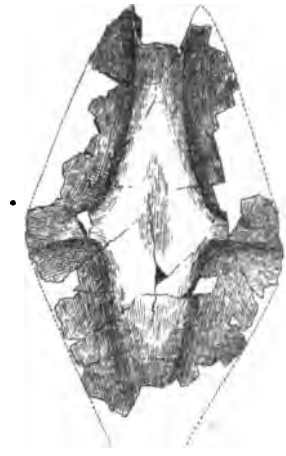

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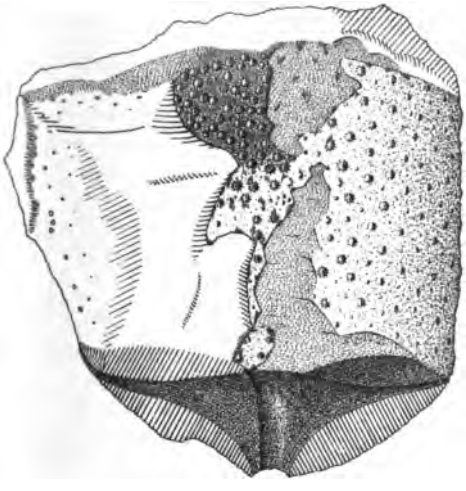

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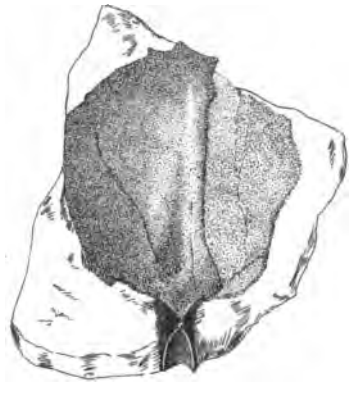

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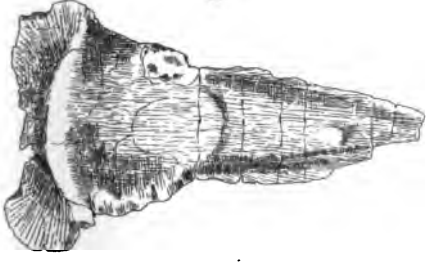

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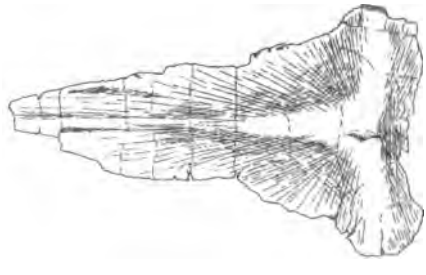

Heliotype Co., Boston.

PLATE 3.

Fig. 1. *Dinichthys* (?) *intermedius* Newb. × ¾. Cleveland Shale; Lindale, Ohio. M. C. Z., Cat. No. 1380. External aspect of supposed antero-ventro-median plate.

Fig. 2. *Dinichthys terrelli* Newb. × ½. Cleveland Shale; Lorain County, Ohio. M. C. Z., Cat. No. 1315. Posterior aspect of carinal process belonging to a large-sized dorso-median, viewed in a vertical position. The semicircular incision below, where it overrode the vertebral axis, its massive character, and depth of posterior cavity, are remarkable. It projects downward and backward at an angle of about 60° with the plane of the dorso-median, traced along the median line of the back.

Fig. 3. *Dinichthys eifeliensis* Kayser. × ½. Middle Devonian; Berndorf, near Hillesheim, Eifel District. M. C. Z., Cat. No. 1374. Carinal process detached from dorso-median plate.

Fig. 4. *Dinichthys pustulosus* sp. nov. × ½. Hamilton Limestone; Cement Quarries, Milwaukee, Wisconsin. M. C. Z., Cat. No. 1381. Slightly abraded antero-dorso-lateral plate, showing single sensory canal, and relatively fine tuberculation.

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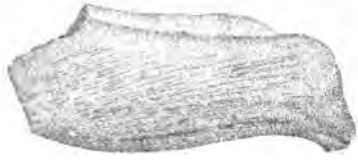

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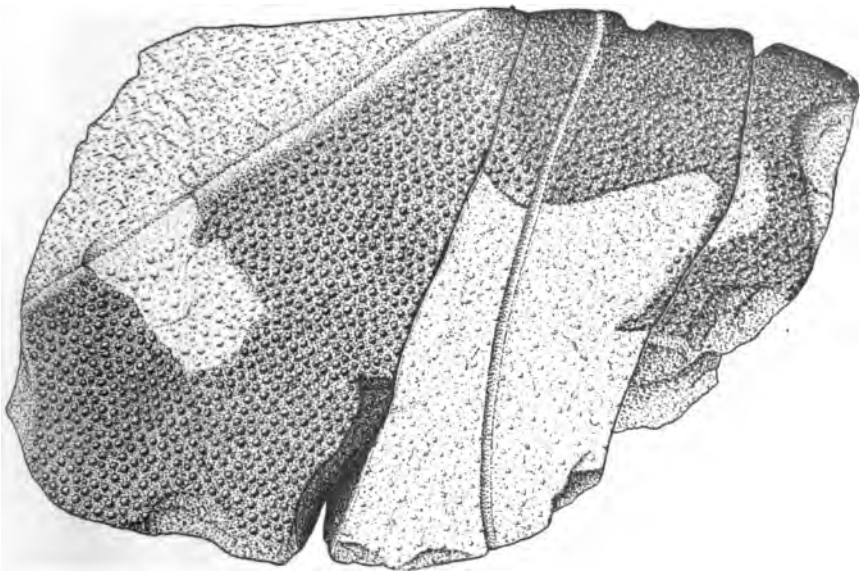

Heliotype Co., Boston

PLATE 4.

Dinichthys (?) *newberryi* Clarke. × ½. Portage Shale; Sturgeon Point, near Buffalo, New York. Weathered plastron and associated fragments. Reproduced from a photograph without retouching.

Heliotype Co., Boston.

PLATE 5.

Fig. 1. Postero-ventro-median plate of an unknown Dinichthyid species. × ⅔ (approximately). M. C. Z., Cat. No. 1475. This plate is preserved in counterpart, and a portion of the bone adheres to the opposite side.

Fig. 2. *Dinichthys* (?) *bohemicus* (Barr.). × ½. Middle Devonian (Étage Gg^1); Chotec, Bohemia. M. C. Z., Cat. No. 1376. Detached dorso-median plate, more highly arched and rounded in outline than that shown in Plate 2, Fig. 3, but having the same ornamentation. The carinal process is slender, and appears only in section where the matrix has been ground away.

Fig. 3. Dorso-median plate of a young individual representing an unknown Dinichthyid species, seen from the under side. × ¾. Cleveland Shale; vicinity of Cleveland, Ohio. Original preserved in Museum of Oberlin College.

Fig. 4. *Dinichthys eifeliensis* Kayser. × ½. Middle Devonian; Eifel District. Internal aspect of right antero-ventro-lateral plate. M. C. Z., Cat. No. 1474.

1.

2.

3.

4.

Heliotype Co., Boston.

The following Publications of the Museum of Comparative Zoölogy are in preparation: —

Reports on the Results of Dredging Operations in 1877, 1878, 1879, and 1880, in charge of ALEXANDER AGASSIZ, by the U. S. Coast Survey Steamer "Blake," as follows: —

E. EHLERS. The Annelids of the "Blake."
C. HARTLAUB. The Comatulæ of the "Blake," with 15 Plates.
H. LUDWIG. The Genus Pentacrinus.
A. E. VERRILL. The Alcyonaria of the "Blake."

Illustrations of North American MARINE INVERTEBRATES, from Drawings by BURKHARDT, SONREL, and A. AGASSIZ, prepared under the Direction of L. AGASSIZ.

A. AGASSIZ. A Visit to the Great Barrier Reef of Australia.

LOUIS CABOT. Immature State of the Odonata, Part IV.
E. L. MARK. Studies on Lepidosteus, continued.
" On Arachnactis.
R. T. HILL. On the Geology of the Isthmus of Panama.
" On the Geology of Jamaica.
On the Geology of the Windward Islands.

Contributions from the ZOÖLOGICAL LABORATORY, in charge of Professor E. L. MARK.

Contributions from the GEOLOGICAL LABORATORY, in charge of Professor N. S. SHALER.

Studies from the NEWPORT MARINE LABORATORY, communicated by ALEXANDER AGASSIZ, as follows: —

A. AGASSIZ and A. G. MAYER. The Acalephs of the East Coast of the United States.
" " " On Dactylometra quinquecirra Agass.
AGASSIZ and WHITMAN. Pelagic Fishes. Part II., with 14 Plates.

Reports on the Results of the Expedition of 1891 of the U. S. Fish Commission Steamer "Albatross," Lieutenant Commander Z. L. TANNER, U. S. N., Commanding, in charge of ALEXANDER AGASSIZ, as follows: —

A. AGASSIZ. The Pelagic Fauna.
" The Echini.
" The Panamic Deep-Sea Fauna.
J. E. BENEDICT. The Annelids.
K. BRANDT. The Sagittæ.
" The Thalassicolæ.
C. CHUN. The Siphonophores.
" The Eyes of Deep-Sea Crustacea.
W. H. DALL. The Molluska.
S. GARMAN. The Fishes.
H. J. HANSEN. The Cirripeds and Isopods.
W. A. HERDMAN. The Ascidians.
S. J. HICKSON. The Antipathids.
W. E. HOYLE. The Cephalopods.
G. VON KOCH. The Deep-Sea Corals.
C. A. KOFOID. Solenogaster.
R. VON LENDENFELD. The Phosphorescent Organs of Fishes.
C. F. LÜTKEN and TH. MORTENSEN. The Ophiuridæ.
O. MAAS. The Acalephs.
E. L. MARK. The Actinarians.
JOHN MURRAY. The Bottom Specimens.
ROBERT RIDGWAY. The Alcoholic Birds.
P. SCHIEMENZ. The Pteropods and Heteropods.
W. PERCY SLADEN. The Starfishes.
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THEO. STUDER. The Alcyonarians.
M. P. A. TRAUTSTEDT. The Salpidæ and Doliolidæ.
E. P. VAN DUZEE. The Halobatidæ.
H. B. WARD. The Sipunculids.
H. V. WILSON. The Sponges.
W. McM. WOODWORTH. The Planarians.

PUBLICATIONS

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

AT HARVARD COLLEGE.

There have been published of the Bulletins Vols. I. to XXX.; of the Memoirs, Vols. I. to XXII.

Vols. XXVIII. and XXXI. of the Bulletin, and Vol. XXIII. of the Memoirs, are now in course of publication.

The Bulletin and Memoirs are devoted to the publication of original work by the Professors and Assistants of the Museum, or investigations carried on by students and others in the different Laboratories of Natural History, and of work by specialists based upon the Museum Collections.

The following publications are in preparation: —

Reports on the Results of Dredging Operations from 1877 to 1880, in charge of Alexander Agassiz, by the U. S. Coast Survey Steamer "Blake," Lieut.-Commander C. D. Sigsbee, U. S. N., and Commander J. R. Bartlett, U. S. N., Commanding.

Reports on the Results of the Expedition of 1891 of the U. S. Fish Commission Steamer "Albatross," Lieut. Commander Z. L. Tanner, U. S. N., Commanding, in charge of Alexander Agassiz.

Contributions from the Zoölogical Laboratory, in charge of Professor E. L. Mark.

Contributions from the Geological Laboratory, in charge of Professor N. S. Shaler.

Studies from the Newport Marine Laboratory, communicated by Alexander Agassiz.

Subscriptions for the publications of the Museum will be received on the following terms: —

For the Bulletin, $4.00 per volume, payable in advance.
For the Memoirs, $8.00 " " "

These publications are issued in numbers at irregular intervals: one volume of the Bulletin (8vo) and half a volume of the Memoirs (4to) usually appear annually. Each number of the Bulletin and of the Memoirs is also sold separately. A price list of the publications of the Museum will be sent on application to the Director of the Museum of Comparative Zoölogy, Cambridge, Mass.

ALEXANDER AGASSIZ, *Director.*

[From The American Journal of Science, Vol. XXXI, May, 1911.]

NEW ELASMOBRANCHS FROM SOLENHOFEN IN THE CARNEGIE MUSEUM.

By C. R. Eastman.

(With Plates I-III.)

ART. XXXIV.—*New Elasmobranchs from Solenhofen in the Carnegie Museum;* by C. R. EASTMAN. (With Plates I–III.)

SEVERAL years ago, through the generosity of Mr. Andrew Carnegie, the Museum founded by him in Pittsburgh received a notable enrichment of its collections illustrative of vertebrate and invertebrate palæontology, especially from European horizons and localities. By its acquisition of the famous Bayet Collection, through the gift of Mr. Carnegie in 1903, the Pittsburgh Museum was at one stroke placed in the front rank of American institutions as regards representation of the ancient life-history of the globe in Old World formations. Remarkable not only for its size and great wealth of fossil species, but also for the excellent character of the material, this collection is one of the largest and scientifically most important that has ever been brought together by a single individual, and in certain respects it stands unrivalled save by the larger public institutions abroad.

The great strength of the Bayet Collection may be said to lie in its magnificent series of vertebrate remains, especially fishes, from European Mesozoic and Tertiary strata. Within this category is to be included first of all the splendid suite of fishes and flying reptiles from the Lithographic limestone (Upper Jura) of Solenhofen, Bavaria, and from the corresponding deposits of Cirin, France. Next in order of importance may be reckoned the fish and reptilian remains (including at least one complete Pterodactyl) from the Lias of central Europe, and "blue Lias" of Dorsetshire. Nor would any mention of this collection be complete which failed to speak of the large variety of exquisitely preserved marine fishes, crocodiles, and plant remains from the Upper Eocene of Monte Bolca, Italy.

So much by way of brief comment on the surprising richness of the collection which has found a final resting-place in the Carnegie Museum, and which embraces the material about to be described in the following pages. For an opportunity to study the entire assortment of fossil fishes belonging to the Carnegie Museum, and for many privileges and courtesies enjoyed during his temporary connection with the institution, the writer is greatly indebted to the kindness of the Director, Dr. W. J. Holland, and desires hereby to express his hearty appreciation of the manner in which work upon the collections has been encouraged and facilitated by Dr. Holland and his assistants.

It is not the purpose of the present article to notice all of the interesting specimens of sharks and rays from Solenhofen

belonging to the Carnegie Museum, but rather to signalize the characters of a few new or little known forms, reserving more detailed descriptions and a review of the entire Upper Jurassic piscine fauna until some later season. The species to which special attention is directed are referable to four genera, as follows: *Cestracion*, *Phorcynus*, *Squatina* and *Rhinobatus*.

Family Cestraciontidæ.

Genus Cestracion Cuvier.

To this existing genus, commonly known as the Port Jackson shark, have been referred certain skeletal remains not as yet satisfactorily distinguished from it which occur in the Lithographic limestone of Bavaria. The holotype of the so-called "*Acrodus falcifer*" (=*Cestracion*) of Wagner is preserved in the Palæontological Museum at Munich, and other imperfect portions of the skeleton are to be seen in the collections of the British Museum. None, however, exhibits the body outline and fin-characters at all satisfactorily.

Cestracion falcifer Wagner.

(For reference to literature see Woodward's Cat. Fossil Fishes British Museum, 1889, pt. 1, p. 332.)

The typical example of this species shows every indication of being an adult individual, and is estimated to have had a total length of about 40^{cm}. In it the two dorsal fin-spines are seen to be of unequal size, both are gently recurved, and the one in advance of the anterior dorsal is inserted at a point about midway between the pectoral arch and the origin of the posterior dorsal fin. It would appear from the published figures, also, that the pelvic fins arise opposite the first dorsal, and the shagreen granules are described by von Zittel as "schaufelförmige oder körnelige," without being markedly differentiated in size. To this species has also been referred by von Zittel (Handb. Palæont. vol. 3, p. 77) a smaller but better preserved individual, having a total length of only 12·5^{cm}, or less than one third as large as the type. According to the author just named, the smaller specimen, which he regards as the young of *C. falcifer*, has feebly striated lateral teeth, and is provided with enlarged stellate tubercles in the dorsal region. The description of this feature reads: "Neben den schaufelförmig gestalteten Chagrinschuppen liegen in der Rückenregion kurze gekrümmte Stacheln, welche sich auf einer vierstrahligen Basis erheben."

It cannot escape notice that the smaller example just referred to presents characters in common with the well preserved

specimen in the Carnegie Museum from the same horizon and locality, immediately to be described as the type of a new species; and it seems proper to associate under the latter head the small shark which the late Geheimrath von Zittel regarded as the young of *C. falcifer*.

Cestracion zitteli, sp. nov.

(Plate I.)

The example which is here regarded as typical of a distinct species merits special attention on account of its being probably the most perfect post-Liassic Cestraciont shark which has thus far been discovered in the fossil state. Agreeing in principal characteristics with the small form described by von Zittel as the young of *C. falcifer*, as above stated, its features are nevertheless judged to be sufficiently distinctive as to warrant a separation from that species.

The more important differences relate to the position of the dorsal fins, form and relative size of the dorsal fin-spines, number and size of the vertebral centra, and presence of a series of enlarged radially ridged and acutely conical shagreen tubercles along the back. A comparison of characters displayed by the dentition in the type specimen of *C. falcifer* is impossible, as the teeth are unfortunately not preserved, but in the small Munich example, which may be with entire propriety associated with the type now under description, the lateral teeth are said to be "mit eine Anzahl von Zacken versehen." This statement may be understood to mean that the oral surface is faintly rugose, transversely striated perhaps, or else that the coronal margin is slightly indented. In any case, however, the teeth must have been exceedingly minute.

A summary of the chief features of interest presented by the type specimen may be given as follows: Form of body slender and elongate, total length from extremity of snout to that of the vertebral column about 15^{cm}. Vertebral centra varying somewhat in length, being more compressed in a longitudinal direction underneath the second dorsal fin. About 25 centra occupy the interval between the bases of the two dorsal fin-spines, and it is noteworthy that these latter abut almost directly against the column, as if they had been deeply implanted in the flesh. The spines themselves are of relatively large size, smooth, sharply pointed distally, and only slightly arcuate or recurved.

Portions of the fin-membrane or shagreen covering of the pectoral pair, as well as the greater part of the pelvic, anal, and caudal fins, are preserved. The anal is nearly opposite the pos-

terior dorsal and, except for being more sharply pointed, resembles it in form and proportions. The pelvic pair is decidedly acuminate, and placed midway between the anal and pectoral pair. The pelvics slightly exceed the second dorsal in size, which latter is somewhat higher and longer than the first dorsal; and the depth of the pectorals is about one-third greater than that of the pelvic pair. Nearly the entire front margin of the right pectoral fin is preserved, but the distal portion of the left pectoral is either concealed or broken away. The same is true of the terminal part of both lobes of the caudal. The general outline of body and position of all the fins is shown in the accompanying illustration (Plate I). In this the shaded area immediately behind the head indicates a piece broken away from the containing rock.

The specific name is bestowed in honor of the memory of the late and deeply lamented Geheimrath Karl von Zittel, of Munich.

Genus Phorcynus Thiollière.

Phorcynus catulinus Thiollière. (Plate II.)

Our knowledge of this species has depended hitherto solely upon the type specimen, which lacks the anal and is in other respects incomplete. It must be regarded, therefore, as an extremely fortunate occurrence that a second and more perfect example of this forerunner of modern Dogfishes should have been discovered a half-century after the first was found, and should provide the means of further enlightenment concerning this genus and species.

The total length of the Carnegie Museum specimen, which bears the catalogue number 4780, is a trifle less than 40^{em}.

It is a little difficult to determine the exact length of the head, but it was apparently contained between five and six times in the total length. The outline of the cranial roof, including the orbits on either side, and that of the lower jaw, is clearly shown. In the ethmoidal region and elsewhere in the body, the rounded or polygonal tesseræ of the endoskeletal cartilage are beautifully displayed, and the same remark applies to the fine shagreen granules occurring throughout the integument. Just beneath the orbital cavity are to be seen impressions of a few minute teeth, each provided with one principal and a pair of lateral cusps.

The vertebral column is preserved intact almost to the extremity of the tail, being flexed upward to support the upper caudal lobe. Ninety-six vertebral centra are to be counted in continuous series, and it is probable that not more than five or six are missing from the posterior extremity. The centra are

of the usual hour-glass form, and do not call for any special comment.

Both the median and paired fins are very well preserved. The pectorals are large, lappet-like, not abruptly truncated distally as in modern representatives of Scyllium, but obtusely pointed, as is the case in Cretaceous species of Palæoscyllium. The low pelvic fins arise at a point opposite the middle of the first dorsal. The endoskeletal supports consist of at least a dozen segmented radialia. The first dorsal arises at about the middle of the back, is of triangular form and moderate height, with twelve or more strong radialia. The second dorsal is similar to the first, but smaller, and the gently rounded anal lies directly beneath its posterior half. The tail is strongly heterocercal, in this respect differing from Palæoscyllium and resembling the recent Ginglymostoma.

A minor feature which deserves perhaps casual mention is the preservation within the intestinal tract, near the vent, of portions of undigested food, including small ganoid scales, fragments of a small finely striated dorsal fin-spine (doubtless the young of some Cestraciont shark), and a number of small Echinoid spines, besides a few Foraminifera tests.

An outline drawing of this highly interesting shark is given in the annexed illustration (Plate II).

Genus Squatina (Aldrovandi) Duméril.

Squatina minor, sp. nov. (Plate III.)

Type. Complete skeleton, Carnegie Museum (Cat. No. 4737).

In general like the contemporary species of *S. alifera*, but distinguished from it by its smaller size (total length 49^{cm}), relatively narrower disk, and more posterior position of both dorsal fins. The first dorsal arises at a point about one-third the distance between the hinder extremity of the pelvic fins and tip of the tail, the second dorsal midway between the latter point and origin of the first dorsal. Dentition and other characters as in the typical species.

The differential characters given in the foregoing diagnosis are considered of sufficient weight to warrant a specific separation between the form here described and its larger contemporary which accompanies it in the same locality, *S. alifera*.

Not more than two or three examples of the latter form have thus far been brought to light, so far as published information shows, and the holotype of the new species here made known is unique. Hence the genus Squatina must be regarded as represented very sparsely, and by not more than three species, at the time of its advent in the Upper Jura of Solenhofen.

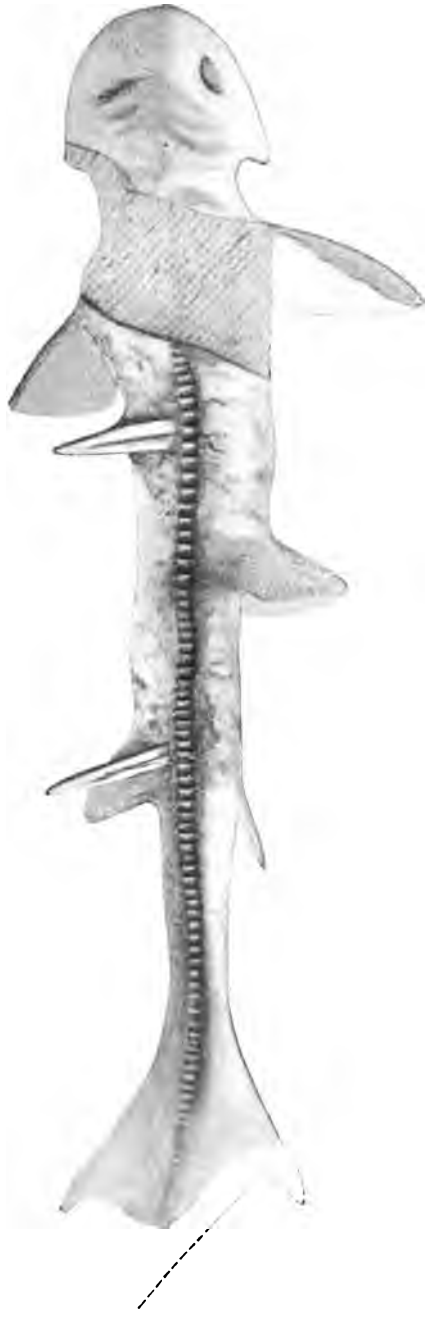
Genus Rhinobatus Bloch (Schneider).

Rhinobatus bugesiacus (Thiollière).

As recognized by Dr. A. Smith Woodward, the type of Wagner's so-called *Spathobatis mirabilis* is only a large variety of this species, which was founded by Thiollière upon a complete skeleton from the Lithographic stone of Cirin (Ain), France.* The Bavarian specimen serving for the type of Wagner's species is a magnificent example measuring $1{\cdot}7^{m}$ in length, with well developed clasping organs, and preserved in counterpart. The original of Wagner's and Zittel's studies is in the Munich Museum, and the opposite half now forms part of the exhibition series of the Carnegie Museum. It is noteworthy as being probably the largest and most perfect example of a fossil ray thus far discovered.

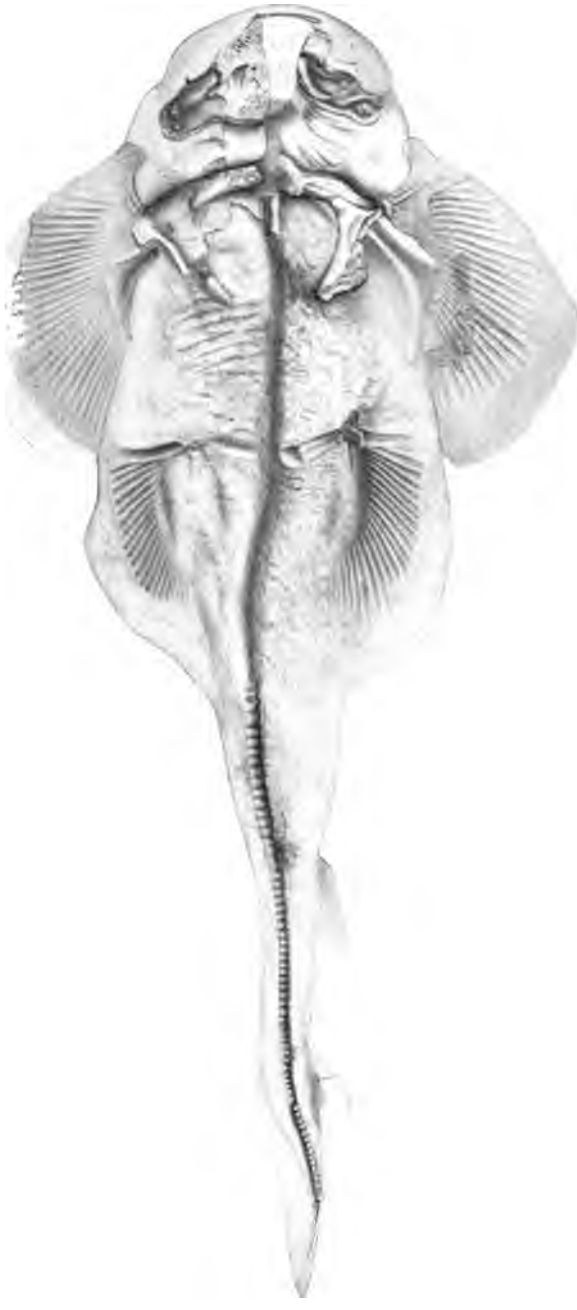
* Thiollière's final work, a large folio published shortly before his death, bears the title: Description des Poissons Fossiles provenant des gisements coralliens du Jura dans le Bugey. Lyons, 1854.

The close affinity between Phorcynus and the type of Wagner's genus Palæoscyllium appears to have been overlooked by students of fossil fishes generally. The former is conjecturally associated with Squatina by Smith Woodward.



Cestracion zittleli, sp. nov. ×7/6. (Carnegie Museum Cat. No. 4423.)

Phorcynus catulinus Thiollière. × 1/2. (Carnegie Museum Cat. No. 4780.)



Squatina minor, sp. nov. × 1/3. (Carnegie Museum Cat. No. 4737.)

JURASSIC SAURIAN REMAINS INGESTED WITHIN FISH.

By C. R. Eastman.

(Issued December 1911.)

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IV. JURASSIC SAURIAN REMAINS INGESTED WITHIN FISH.

BY C. R. EASTMAN.[1]

(Plates X–XI.)

Paleontology affords numberless instances where the nature of the food-supply of various lower and higher vertebrates can be positively determined by the actual stomach-contents which have been preserved within the abdominal cavity of the creatures concerned. These instances are sometimes of special value in confirming *a priori* conclusions respecting the diet of fossil vertebrates based upon the genera character of their dentition. Other cases may attract interest on account of peculiar conditions or associations, which are either to be directly observed, or suggest themselves by inference. Mention should be made, too, of the considerable literature which has grown up within recent years concerning coprolitic matter and so-called "gastroliths," or stomach-stones.

A few of the above-mentioned occurrences are deserving of particular notice, on account of their possessing special points of interest, and because they afford a sort of standard for estimating the importance of a newly discovered case of fossilization about to be described in the present article.

Among mammals, the most familiar instances of the preservation of undigested food in the alimentary tract are furnished by the mammoth and mastodon. A dozen years or so ago much discussion was aroused concerning the possible survival into modern times and domestication by man of the so-called *Neomylodon listai* of Ameghino, or *Grypotherium domesticum* of Roth. Concerning the antiquity of the remains that have been described under these names, the last word would seem to have been spoken by Dr. A. S. Woodward in

[1] An abstract of this article was presented at the annual meeting of the Paleontological Society, held at Washington, D. C., December 28, 1911.—Editor.

[2] On a portion of a mammalian skin, named *Neomylodon listai*. *Proc. Zool. Soc.*, London, 1899, p. 154. Exhibition of newly discovered remains of *Neomylodon* from Patagonia. Rept. 69th Meet. Brit. Assoc. Adv. Sci., Dover, p. 783.

articles published jointly with Dr. F. P. Moreno.[2] The idea that some of these creatures found in caverns of Patagonia were stall-fed, being kept in captivity by aboriginal inhabitants, received credence through the finding of vegetable fibers resembling chopped hay in association with their mummified remains.

Writing in 1900, Nordenskjold,[3] after an examination of the dung of one of these sloths, announced the following conclusion: "Le contenu des excréments montre que cet animal se nourissait d'herbes et pas de feuilles et qu'il mâchait et digeraitmal sa nourriture." That the author just quoted does not err on the side of rashness may be judged from the following non-committal remark: "Quant à la question de savoir si le Glossotherium a été contemporain de l'homme, je n'ose pas encore répondre définitivement."

Among reptiles, the most numerous and best authenticated cases where the nature of the food-supply is determinable, either from ingested prey, or from hard parts, such as scales, teeth, etc., preserved within coprolites,[4] occur within the order Ichthyosauria. The question as to whether all so-called "embryoes" included within the abdominal cavity of *Ichthyosaurus* are really fœtal, or are not in part at least young reptiles that have been swallowed, has been recently discussed by Branca.[5] A similar question in regard to the supposed embryo contained within the body of the type specimen of *Compsognathus* was raised not long since by Dr. Franz Nopsca.[6] If Marsh's original interpretation of this interesting specimen be set aside, no positive evidence remains that Dinosaurs were viviparous.

Turning our attention to the class of fishes, instances are known where distinctly recognizable skeletons of bony fishes are preserved within the intestinal tract of fossil sharks. A striking example is that of *Carcharias* (*Scoliodon*) in the Bologna Museum. The wonder-

[2] Nordenskjöld, E., La Grotte du Glossotherium (Neomylodon) en Patagonie. *Bull. Soc. Géol. France*, 1900 [3], vol. 28, pp. 29–32. See also Hatcher, J. B., The Mysterious Mammal of Patagonia. *Science*, N. S., 1899, vol. 10, pp. 814–815.

[4] For an exhaustive investigation of reptilian coprolitic matter from the Wealden of Belgium one may refer to a contribution by M. Bertrand, entitled "*Les coprolithes de Bernissart.*" Mém. Musée Roy. Belg. d'Hist. Nat., Vol. I, 1903.

[5] Branca, W. Two papers published 1907–8 in Abh. Akad. Wiss. Berlin, Phys. Abh. No. 3, and Sitzber. Akad. Wiss. Berlin, pp. 392–6. The latter is entitled "*Nachtrag zur Embryonenfrage bei Ichthyosaurus.*"

[6] *Neues Jahrb. f. Min.*, 1903, Supplement, vol. 16, pp. 476–494. See also the following: F. v. Huene, "*Der vermuthliche Hautpanzer des Compsognathus longipes Wagn.*" *Ibid.*, 1901, vol. 1, pp. 157–160.

ful preservation of muscle fibers and other soft parts in the Upper Devonian *Cladoselache* encourages the expectation that further light may be forthcoming respecting the food-habits of that primeval shark.

Very peculiar conditions have been observed by Campbell Brown in the case of a Liassic shark, *Hybodus*, which had apparently encountered a swarm of immature belemnites and proceeded to make a meal of them. In this connection the author states: "Das gefrässige Thier war augenscheinlich in einen dichten Schwarm kleinerer Belemniten gerathen und hatte sich mit denselben vollgestopft. Bei der Verdauung traten dann Beschwerden ein. Belemnitenrostra sind nicht gerade besonders geeignet, die Spiralklappe im Colon eines kleinen Haifisches zu passiren, besonders wenn mehrere Hundert zu gleicher Zeit im Magen liegen. Der Tod des Haies kann nicht überraschen!"[7]

Among teleostean fishes, it is not uncommon to find specimens showing the particular nature of their stomach contents. The predaceous ganoid *Caturus*, from the Upper Jura of Solenhofen, very often contains recognizable portions of *Leptolepis* within the abdominal cavity. In the Paris Museum of Natural History is preserved a slab containing two individuals of *Blochius*, from the Eocene of Monte Bolca, the larger one having apparently partially swallowed the other. Agassiz, however, states that the appearances are deceptive, and that the two individuals may have chanced to become superimposed one upon the other in a rather striking attitude. Nevertheless he remarks:[8] "Je ne prétend pas nier d'une manière absolue la possibilité d'une pareille coïncidence."

We have now to consider the very singular, if not indeed unique conditions presented by two specimens of Jurassic fishes belonging to the Bayet collection of the Carnegie Museum. The first of these which invites attention is a form, referable to the genus *Belonostomus* (Plate X), from the Lithographic Stone (Lower Kimmeridgian) of Cerin, in southeastern France. The species, judging from the slender proportions of the head, in which the snout is greatly elongated, is probably to be identified as *B. tenuirostris* Agassiz, but it is evidently an immature example, the total length of which probably did not exceed 16 cm. The caudal region is lacking, but the head and anterior part of the trunk are very clearly shown. The scales, cranial and

[7] Brown, C. "*Ueber das Genus Hybodus und seine systematische Stellung.*" Palaeontogr., 1900, vol. 46, p. 163.

[8] Agassiz, L. "*Poissons Fossiles,*" 1844, vol. 2, pt. 2, p. 257.

facial bones, and vertebral centra would seem to be preserved partly in the form of an impression, partly as structures in which the external surface has been eroded away, or removed by chemical action.

The fish itself would not be remarkable, except for the circumstance that it happens to contain the skeletal remains of a small Rhynchocephalian reptile, probably *Homœosaurus*, within the abdominal cavity. The prey had been gulped down head first, and may have caused the death of the fish, as the digestive process had not advanced far enough to dismember the limbs nor to disturb the natural position of parts beyond a slight lateral compression of the trunk. The surface characters of the head are shown with tolerable distinctness, a depression is indicated which may be the pineal foramen, and a few slender teeth are exposed on one side anteriorly. The vertebral column of the reptile is preserved for some distance beyond the sacral region, and some of the anterior limb-bones are clearly visible. It is hoped that the accompanying plate (Pl. X) may aid in rendering the above-described conditions more intelligible to the reader.

The second specimen referred to, which is worthy of notice in this connection, likewise forms part of the Bayet collection, and was derived from the same horizon and locality as the first. It is a very complete teleostean skeleton, having a total length of 19 cm., and is preserved in the form of remarkably sharp counterpart impressions in a slab of lithographic limestone. The systematic position of the fish represented is very close to that of the type species of the so-called genus *Attakeopsis*, established by Victor Thiollière in 1858, but regarded by the late Karl von Zittel, Dr. A. Smith Woodward, and others as identical with the earlier described *Oeonoscopus* of O. G. Costa (Ittiol. Foss. Italia, 1853, p. 2). The example under discussion appears, however, to present more than individual differences from the solitary known species of *Oeonoscopus* occurring in the Cerin lithographic limestone, and is accordingly regarded as representing a distinct species.

The distinguishing characters of the new form, which may be designated as *O. elongatus*, are included in the following brief diagnosis:

Oeonoscopus elongatus, sp. nov.

(Plate XI.)

Type.—Nearly complete fish in counterpart: Carnegie Museum Cat. Nos. 4079 + 4079*a*.

A small species, attaining a total length of about 20 cm., and distinguished from all others belonging to the same genus by its slender and elongated form of body, and by the more anterior position of the dorsal fin, which arises opposite the pelvic pair, and does not extend back of a point midway between them and the insertion of the anal. Length of the head with opercular apparatus exceeding the maximum depth of the trunk, and contained about five times in the total length of the fish. Vertebræ about fifty in number, with strong neural and hæmal spines. A single large ridge-scale at the upper and lower borders of the caudal pedicle. Teeth small and conical. All fins relatively small, caudal lobes not much expanded. Scales indistinctly shown.

One of the halves of the counterpart in which this specimen is contained is illustrated in the accompanying plate, the original drawing having been made by Mr. Sidney Prentice. Within the abdominal cavity, or more particularly, within that part of it lying between the paired fins, is to be seen a tolerably distinct impression of a small reptile resembling a Lacertilian, the precise nature of which is indeterminate, but very probably is akin to *Homœosaurus*. Only the head and anterior ~~position~~ of the vertebral column are clearly recognizable, and it is noteworthy that the creature appears to have been swallowed tail foremost, whereas in the first described specimen the position of parts is reversed. The size of the ingested remains is practically the same in the case of both specimens.

So far as the present writer is aware, these two are the only instances afforded by paleontology where fossil reptiles happen to have become preserved within the abdominal cavities of fish. These occurrences are all the more remarkable, when it is remembered that the contained reptiles were terrestrial, and their ichthyic foes marine in habitat. This apparent anomaly may perhaps be accounted for by supposing the primitive lizards in question to have inhabited the shores of coral islands in the late Jurassic sea, which covered central Europe at the time. One may suppose the prey to have been captured in proximity to land, or possibly the terrestrial creatures were carried out to sea by floating vegetation to which they had clung, and were seized at a distance from land. The latter hypothesis finds perhaps a certain degree of plausibility from the abundance of plant remains which are known to occur at the Cerin locality.

The two specimens which are described and portrayed in the present

article form part of a representative and extremely important collection of fossil remains, both vertebrate and invertebrate, from the Lithographic Stone (Lower Kimmeridgian) of southeastern France and Bavaria. The whole of this superb collection was purchased some eight years ago from Baron Ernst de Bayet of Brussels by Mr. Andrew Carnegie, and generously presented by him to the institution founded by him in Pittsburgh.

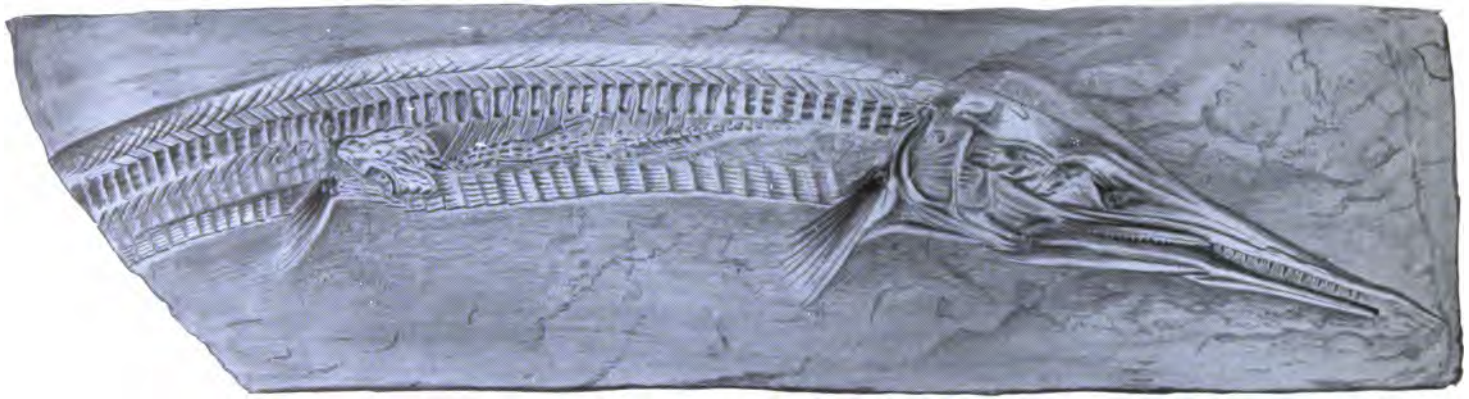
EXPLANATION OF PLATES.

PLATE X.

Belonostomus tenuirostris Agassiz *juv.* Lithographic Stone; Cerin (Ain), France. Head and anterior portion of the trunk of an immature individual apparently belonging to this species, within the abdominal cavity of which is contained the skeleton of a small Rhynchocephalian reptile, probably *Homœosaurus*. The prey has been swallowed by the fish headforemost. The head, anterior limbs, and greater part of the vertebral column of the contained reptile are very clearly shown. Car. Mus. Cat. No. 4080. × $\frac{1}{1}$.

PLATE XI.

Oeonoscopus elongatus, sp. nov. Lithographic Stone; Cerin (Ain), France. Holotype, preserved in counterpart, showing an imperfectly preserved Rhynchocephalian skeleton within the abdominal cavity. Car. Mus. Cat. No. 4079. × $\frac{5}{7}$.



Belonostomus tenuirostris Agassiz *juv.* × $\frac{5}{7}$.

Oeonoscopus elongatus, sp. nov. (Type). × $\frac{1}{1}$.

(*Proceedings of the Paleontological Society*)

MESOZOIC AND CENOZOIC FISHES

BY

C. R. EASTMAN

[Reprinted from the BULLETIN OF THE GEOLOGICAL SOCIETY OF AMERICA, Vol. 23, pp. 228–232. Published June 1, 1912]

MESOZOIC AND CENOZOIC FISHES

BY C. R. EASTMAN

Among the more important general results that have been gained during the last decade from a study of the several piscine faunas occurring throughout the Mesozoic and Cenozoic eras, the following are worthy of attention:

With the advent of the Mesozoic, that is to say, in the early Trias, fishes of a higher grade in the scale of progressive evolution make their appearance than those which were dominant during the Paleozoic. Among Actinopterygian fishes the ancient race of Paleoniscids continues, it is true, but the group is marked by degeneracy in the direction of modern sturgeons, and the incoming Protospondyli of the Trias develop a number of series, which in the fullness of time become molded into the characteristic types of Upper Cretaceous and Tertiary fishes, in the end becoming transformed into our present-day fauna.

These large-mouthed Protospondyli with conical teeth, which are traceable from the Trias onward until they pass almost imperceptibly into modern bony fishes, constitute at least three important families—the Eugnathidæ, Amiidæ, and Pachycormidæ. It is interesting to note that the last mentioned of these is represented in the Alpine Middle Trias by the genus *Urolepis*, which shows considerable resemblance to the Paleoniscids. The Pacycormidæ in particular show distinct evidence of gradual progression as they are traced upward in their geological range.

During the Jurassic the next higher suborder appears, that of the Isospondyli, characterized by a simplified mandible and a more completely ossified internal skeleton. The teleostomes which acquire this new and advanced type of skeletal frame soon give rise to a varied series of families and begin to predominate in the Cretaceous ichthyic fauna. Until this time, as remarked by one of our foremost authorities on paleichthyology, Dr. A. Smith Woodward, "the skull of the Actinopterygii had always been remarkably uniform in type, . . . the pelvic fins

always retained their primitive remote situation, and the fin-rays never became spines. During the Cretaceous period the majority of the bony fishes began to exhibit modifications in all these characters, and the changes occurred so rapidly that, by the dawn of the Eocene period, the diversity observable in the dominant fish fauna was much greater than it had ever been before. At this remote epoch, indeed, nearly all the great groups of bony fishes, as represented in the existing world, were already differentiated, and their subsequent modifications have been of quite a minor character."

The general course of evolution observable among fishes being as above briefly summarized, it has been the aim of specialists during the past decade to work out the details of classification with ever increasing accuracy, as far as the existing state of our knowledge will permit. A further object of study has been to gather more precise information regarding the anatomical structure of the different forms whose remains have been preserved, whether in the entire, or crushed and fragmentary condition; and towards this end a vast deal of material has been accumulated. Still another objective point, and one more difficult of attainment, has been to trace the stages of differentiation passed through by the dominant Tertiary fishes, which in turn gave rise to the modern fauna.

In connection with the latter problem, an interesting allied topic has presented itself for investigation, namely, that of the antiquity of the deep-sea fish fauna. It is now well recognized that among marine organisms many forms which have been worsted in the unceasing struggle for existence—waged always most keenly along the shorelines of continents—manage to survive through having emigrated elsewhere, amid less trying conditions. Divers groups of animals, for instance, have been forced to seek a refuge in fresh waters, and have there continued to persist, some dwindling, others flourishing, according to their ability to react in response to changed environment. Other groups, and among them many fishes, have been driven into tenanting the abysmal depths of the ocean.

Paleontology shows that the last mentioned refuge was not inhabited to any great extent by fishes prior to the latter part of the Cretaceous. But, beginning during this period and steadily proceeding until the present day, a gradual migration of certain groups of fishes into great depths of the ocean has been in progress, coincident with remarkably striking changes in the anatomical structure of the emigrant outcasts. As a result of recent researches, more especially of the late Cretaceous and Eocene deep-sea fish faunas, we are enabled to note the gradually changing constitution of these abyssal assemblages from the close of the

Mesozoic onward to our own day. Mention may be made at this point of at least one specimen of *Dercetis*[1] from the Lebanon Cretaceous which seems to prove that some of these deep-sea fishes were provided with a distensible stomach, as is commonly true of modern forms.

To pass in review the large series of important contributions to the literature of Mesozoic and Cenozoic fishes that has appeared during the past decade would exceed the limits assigned to the present article. Nevertheless a few words may be said concerning the nature of the publications covering these topics. The greater number of memoirs consists of those which take account of the entire assemblage of fossil fishes occurring within certain stratigraphic horizons—that is to say, the subject-matter is treated from the faunistic standpoint, including descriptions of new genera and species. Less in number, but paramount in interest and importance, are the series of papers whose purpose it is to elucidate the structure of particular fossil forms, to inquire into their systematic relations and phylogeny, or to throw light on various matters relating to their environment, distribution, and the like. Among the latter class of contributions may be mentioned, for instance, the papers by Abel[2] and Dollo[3] on extinct flying-fishes, those by Campbell Brown[4] and Ernst Koken[5] on the genus Hybodus, one by Erwin Hennig[6] on Pycnodonts, another by Rudolf Cramer[7] on Eocene species of *Mene*, Bassani's memoir on *Myripristis*,[8] and similar studies by other Italian authors.

A bare enumeration of titles of some of the more important faunistic monographs that have enriched the literature within the last ten years must suffice for the present article. Among memoirs devoted to Triassic fish faunas, those by Bassani, Schellwien, Kramberger, and De-Alessandri[9] are of the highest excellence. In this country the Triassic fish faunas of New Jersey and Connecticut have been reviewed in bulletins published by the State geological surveys of those commonwealths, and the con-

[1] This specimen is figured by A. S. Woodward in Natural Science, 1898, vol. xii, pl. x.

[2] O. Abel: Fossile Flugfische. Verh. deutsch. Zool. Ges., 15ten Vers., 1905, pp. 47-48.

[3] L. Dollo: Les poissons volliers. Zool. Jahrb., Abth. Syst., 1909, vol. xxvii, pp. 419-438.

[4] C. Brown: Ueber das Genus Hybodus und seine systematische Stellung. Palæontogr., 1900, vol. xlvi, pp. 149-175.

[5] E. Koken: Ueber Hybodus. Geol. Palæont. Abhandl., 1907, n. s., vol. v, pp. 1-18.

[6] E. Hennig: Gyrodus und die Organisation der Pyknodonten. Palæontogr., 1906, vol. liii, pp. 137-208.

[7] R. Cramer: *Mene rhombeus* (Volta). Zeitschr. deutsch. geol. Ges., 1906, vol. lviii.

[8] F. Bassani: Sopra un Bericide del calcare miocenico di Lecce, etc. Atti della R. Accad. Scienze di Napoli, 1911, vol. xv, pp. 1-15.

[9] G. De-Alessandri: Studii sui pesci triasici della Lombardia. Mem. Soc. Ital. Sci. Nat., 1910, vol. vii, pp. 1-147.

temporary faunas of the Pacific slope have been treated in publications of the University of California. Turning to the African continent, the writings of Dr. Broom[10] and others have enlightened us with regard to the fossil fishes of the Upper Karroo beds.

Jurassic fishes have continued to receive attention during the past decade, though for the most part in the form of short papers, like those of Dr. A. Smith Woodward and others in England. A notable contribution on the fauna of the lithographic limestone of Bavaria is that by Dr. Erich Heineke.[11] Reference may be made in this connection to Dr. Walther's interesting discussion of the Solenhofen fauna, to be found in the anniversary volume in honor of Professor Ernst Haeckel.

The Wealden fishes of Belgium have recently been studied by the veteran Scottish ichthyologist, Dr. R. H. Traquair.[12] Of the first order of importance is the splendid monograph on British Cretaceous Fishes, by Dr. A. S. Woodward, published by the Palæontographical Society. To the same author students are indebted for a number of illuminating papers on the Cretaceous fishes of Lebanon and other localities, as well as for the concluding volume of that most indispensable of all works on the subject of fossil fishes, the Catalogue of the British Museum (vol. iv, 1901). The researches of Professor F. Priem, of Paris, have extended not only over the Cretaceous fish faunas of France, northern Africa, and Persia (1908), but we are indebted to him and to Dr. Maurice Leriche, of Lille, for a revision of the extensive Tertiary fish faunas of Franco-Belgian territory. In this country the only recent publication on Cretaceous fishes is contained in Bulletin 4 of the Geological Survey of New Jersey, the full title of the paper being "A Description of the Fossil Fish Remains of the Cretaceous, Eocene and Miocene Formations of New Jersey," by Henry W. Fowler (1911).

The recent literature of Tertiary fishes is not very extensive, the principal memoirs being those by Priem and Leriche, already referred to. The Eocene fish fauna of Monte Bolca, in northern Italy, has received renewed attention on the part of several writers, one of the memoirs dealing with the type specimens in the Paris Museum; and several contributions have appeared on the Tertiary fishes of northern Africa (Priem, Stromer), Australia (Chapman), and South America (Woodward, Sangiorgi, De-Alessandri). In this country, the Eocene

[10] R. Broom: The fossil fishes of the Upper Karroo Beds of South Africa. Ann. South African Mus., 1901, vol. 7, pp. 251-269.

[11] E. Heineke: Die Ganoiden und Teleostier des lithographischen Schiefers von Nusplingen. Geol. Pal. Abhandl., 1907, vol. xii, pp. 159-214.

[12] Les poissons wealdiens de Bernissart. Mém. Mus. Roy. d'Hist. Nat. Belg., 1911 (Année 1910), vol. vi, pp. 1-65.

and Miocene fish faunas of Maryland and New Jersey have been described in reports published by the geological surveys of these States, and several minor contributions have appeared on Tertiary fishes from the western States, more especially Colorado, Nevada, and California. Most recently of all, President D. S. Jordan[13] has described an interesting collection of fish remains from presumably Lower Eocene deposits of Bahia, Brazil, thus supplementing his earlier studies in conjunction with Professor Branner upon the Cretaceous Fishes of the Province of Ceará, Brazil (1908). During the year just closed, also, fresh discoveries of Tertiary fishes have been reported from Kamerun, from near Benito, in the French Congo, and elsewhere on the west coast of equatorial Africa.

[13] D. S. Jordan: Description of a collection of Fossil Fishes from the Bituminous Shales at Riacho Doce, State of Alagôas, Brazil. Annals Carnegie Museum, 1911, vol. vii, No. 2.

TERTIARY FISH-REMAINS FROM SPANISH GUINEA IN WEST AFRICA.

By C. R. Eastman.

(Issued July 16, 1912.)

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XII. TERTIARY FISH-REMAINS FROM SPANISH GUINEA IN WEST AFRICA.

By C. R. EASTMAN.

Plates XXIII–XXIV.

In May, 1911, a shipment of natural history specimens was received by the Carnegie Museum which had been collected by Rev. A. I. Good, a missionary stationed at Benito, in Spanish Guinea, and by him forwarded to Director W. J. Holland in the fall of 1910.

The collections made by Mr. Good for the Carnegie Museum are chiefly entomological, but, included among the lot of insects and other objects illustrating the natural history of the region, were found a number of slabs of dark-colored fissile shale, containing an abundance of carbonaceous matter, with here and there a few small-sized concretions, valves of Entomostraca, and portions of Teleost fish-skeletons, these last being comparatively numerous.

The amount of carbonaceous matter present in the rock is so great that the shales might properly be called bituminous, and appearances indicate very strongly that they are of lacustrine, or perhaps estuarine origin, certainly not marine, and were deposited in a rather shallow basin. No means are at hand for determining the geological age of the strata except the evidence furnished by the remains of the fishes embedded within the shale, and they betoken an early Tertiary horizon, probably at least as early as the dawn of the Eocene. The geology of the region about Benito has not been studied or described, so far as the writer is aware, but it is a well-known fact that isolated patches of Tertiary rock occur frequently along the eastern and western coasts of Africa, and their distribution is indicated in a general way by Walcot Gibson in a sketch-map of the geology of the continent to be found in the first volume of the new Encyclopedia Britannica.[1]

[1] The marine strata of the early Tertiary of South Togo, in West Africa, have furnished a number of vertebrate remains which are described by Dr. Ernst Stromer, of Munich (*Zeitschr. deutsch. geol. Ges.*, Vol. LXII, 1910, pp. 478–508). More recently the same writer has contributed a note entitled "Funde fossiler Fische in dem tropischen Westafrica" (Centralbl. f. Min., etc., Jahrg. 1912, no. 3, pp. 87, 88), which mentions the discovery of fragmentary Teleost and Silurid fish-remains from near the mouth of the River Benito in Spanish Guinea, without, however, offering detailed descriptions of them.

Although dissociated parts of fish skeletons are present in considerable abundance in the fragmentary blocks of shale which make up the collection, and the appearance of these detached parts suggests that the remains have been subjected to a moderate amount of current action prior to fossilization, yet the number of species represented does not exceed three or four, and even the best preserved individuals are far from being complete. Nevertheless, the Clupeoid nature of most of the remains is easily recognizable, and in the case of the largest and best preserved species it is possible to work out nearly the entire structural organization by combining the data derived from a study of several individuals whose parts fortunately supplement one another.

Scanty as these newly discovered remains are, their bearing upon broad philosophical problems, such as the origin of modern fresh-water faunas on either side of the Atlantic, conditions affecting distribution in times past, and the theory of a former land connection between tropical America and Africa, is of prime importance. This must necessarily be so by virtue of their being the first indication yet reported of a post-Triassic fish-fauna in tropical or South Africa. We cannot forbear to note that only a few years ago, in 1905, our want of knowledge on such matters drew from Dr. Boulenger the following remarks: " It remains a matter for serious regret that we should still be without any information as to the precursors of the African fishes. In spite of diligent search over a considerable portion of the great continent, no remains of any post-Triassic fishes have yet been discovered in Tropical and South Africa, and our acquaintance with Tertiary Teleosts generally is still almost as scanty and fragmentary as it was twenty years ago, although much has been done by Dr. Smith Woodward in elucidating the affinities of such remains as have been exhumed. Under the circumstances we have to fall back on our imagination to explain the fauna, and much hazardous speculation has been indulged in."[2]

The species of fossil Teleosts in Mr. Good's collection which lends itself most readily to examination is evidently new to science, and belongs to the genus *Diplomystus*. It is described in the following pages under the appellation of *D. goodi*, the writer having pleasure in naming it at the suggestion of Dr. W. J. Holland in honor of the

[2]Boulenger, G. A., The Distribution of African Fresh-water Fishes. Presidential Address, Rept. Brit. Assoc. Adv. Sci., South African Meeting, 1905.

discoverer. A smaller form represented by several badly crushed and distorted individuals resembles more or less closely some of the remains which Dr. D. S. Jordan has recently described from the bituminous (Tertiary?) shales at Riacho Doce, State of Alagôas, Brazil, under the generic title of *Ellipes*. The latter is doubtfully distinct from *Diplomystus*, but may perhaps be retained provisionally as a subgenus of the latter. A single specimen in the collection is doubtfully identifiable as belonging to *Enchodus*.

Regarding the Brazilian fish-remains described by Dr. Jordan, their discoverer, Professor J. C. Branner, offers the following comments in his paper on the Geology of Alagôas, which accompanies that of Dr. Jordan in volume VII of the ANNALS of this Museum.

" Dr. Jordan feels some doubt in regard to the exact age of the beds, and he ventures only to say that ' the shales of the Riacho Doce were deposited in an estuary and that their age is Cretaceous or Lower Eocene, possibly Upper Cretaceous.'

" These fishes form the most important collection of fossils thus far made in the state of Alagôas, and they also make an interesting and valuable contribution to our knowledge of the coast sediments of eastern Brazil " (*loc. cit.*, p. 18).

Now it is an interesting and significant fact that species of the same genus, or at least of very closely related genera, should occur respectively in fresh-water deposits of the eastern coast of South America and western coast of Africa, the presumption being that the strata are approximately contemporaneous,—that is to say, early Tertiary. This coincidence points to a similarity of the fresh-water fish-faunas of the two continents extending as far back as the dawn of Tertiary time, and also suggests a correspondence of geological history between the land-masses on either side of the Atlantic.

An hypothesis which has recently found strong adherents among ichthyologists is that put forward by von Ihering and others, which postulates a late Cretaceous or early Tertiary land-bridge between tropical Africa and South America, possibly in contact with Guiana in the latter continent. This conjectural land-mass, " Helenis," may be supposed to have been populated by the ancestors of modern fresh-water fishes of tropical America, among others by the Lepidosirenidæ, Characinidæ, Cichlidæ, and Siluridæ. A submergence of the area called Helenis took place during Tertiary times, which brought about important changes in the ichthyic fauna, such for instance as

are described by Dr. Eigenmann as follows: " This land-mass sank beneath the surface of the ocean, forcing the fauna in two directions, towards Africa and towards South America, exterminating all types not moved to the east or the west. From these two rudiments have developed the present diverse faunæ of Africa and South America, each reinforced by intrusives from the ocean and neighboring land areas by autochthonous development within its own border. The one fauna cannot be said to have been derived directly from the other. The connection between Africa and South America existed before the origin of the present genera and even before the origin of some of the present subfamilies and families, some time before the earlier Tertiary. There has never been any exchange between Africa and South America since that time."[3]

Elsewhere in the same article the author whom we have just quoted remarks: " There has been a remarkable parallelism in the evolution of genera of cichlids, characins, and catfishes on the two continents. . . . The Cichlidæ are abundant in tropical America and Africa, a few species of Cichlidæ being also found in India. There is no means by which these two forms could have crossed the existing gap between Africa and South America. There has been no exchange of species in recent times, for there is no species or genus common to the two continents. The South American and African elements of these two families must have been derived from some intermediate land-mass or must have gone from one continent to the other over a land-bridge."

It may not be amiss to consider here somewhat briefly the present and former distribution of the genus *Diplomystus*, which is a typical example of the double-armored herrings. *Diplomystus dentatus*, the type species, was described by E. D. Cope in 1877 from the Middle Eocene (Green River) fresh-water deposits, and at the same time two previously described Clupeoids which accompany it in the same horizon and locality were transferred to the new genus. These were the so-called *Clupea humilis* and *C. altus* of Leidy. Cope recognized that the species comprised by *Diplomystus* might be divided into two sections, distinguished by the form of their dorsal ridge-scales. " In section I," he observes, " these shields are transverse and their posterior borders are pectinate, a median tooth being especially prominent. In section II, the scuta are not wider than long, and

[3] Eigenmann, C. H., The Fresh-water Fishes of South and Middle America *Pop. Sci. Monthly*, Vol. LXVIII, No. 6, 1906, p. 528.

have but one, a median tooth, which is the extremity of a long median longitudinal carina. The species of section I are *D. dentatus*, *D. analis* and *D. pectorosus;* those of section II are *D. humilis* and *D. altus*."[4]

It remained for President Jordan, thirty years later, to give validity to the distinction just noticed by elevating Cope's "section II" of the genus *Diplomystus* to the rank of an independent genus (or subgenus, as suggested in the ANNALS OF THE CARNEGIE MUSEUM, Vol. VII, 1910). This was named *Knightia*,[5] the species chosen for its type being the previously described *Clupea humilis* of Leidy, afterward renamed *C. pusilla* by Cope. Dr. Jordan substituted the new specific title *eocena* for that bestowed upon the species by the original author, the combinations of *Clupea humilis* and *Clupea pusilla* being preoccupied among recent fishes. In this connection it should be remarked that the name *Diplomyste* Bleeker (= *Diplomystax* Günther, and *Diplomystęs* Duméril) refers to an existing genus of South American Silurids, and is not to be confused with the term proposed by Cope. *Copeichthys* of Dollo (Results Voyage Belgica, 1904, p. 159) is a synonym of *Diplomystus*, the former name having been substituted under an erroneous idea that Cope's term was preoccupied.

Other occurrences of *Diplomystus* in the fossil state are in the Upper Cretaceous of the Lebanon, Istria, Dalmatia, and Brazil; in the Lower Oligocene (Osborne beds) of the Isle of Wight; and in the supposed late Cretaceous or early Tertiary fresh-water shales at Riacho Doce, Brazil (two species described by Jordan as *Ellipes branneri* and *E. riacensis*).[6]

Besides the above mentioned fossil forms, a recent Diplomystid which has been described under the name of *Clupea* (*Hyperlophus*)

[4] Cope, E. D., A Contribution to Our Knowledge of the Ichthyological Fauna of the Green River Shales, *Bull. U. S. Geol. Survey Territ.*, Vol. III, 1877, p. 808.

[5] Univ. Cal. Publ., V, No. 7, p. 136, 1907.

[6] Regarding *Ellipes* Dr. Jordan remarks in the paper above cited: "In any event I think that we are justified in recognizing *Ellipes*, *Potamalosa*, *Hyperlophus* and *Knightia* as distinct subgenera, even if we should wish to place all double-armored herrings in the single genus, *Diplomystus*" (*l. c.*, p. 25).

In Dr. Jordan's scheme Cope's species *D. longicostatus*, from the Upper Cretaceous of Bahia, Brazil, finds a place under the new generic or subgeneric caption of *Ellipes*. It is doubtful, however, if the proposed separation can be maintained in actual practice, as the majority of specimens fail to disclose the characters relied upon for distinctive criteria.

spratellides[7] occurs in the river system of New South Wales, and is said also to inhabit certain rivers along the western coast of South America, especially in Chili. The distinctive character of the so-called "*Hyperlophus*," as contrasted with *Clupea*, consists in the presence of a series of enlarged dorsal scutes extending between the occiput and origin of the dorsal fin. In other words, it is a double-armored herring, and differs from the single-armored in precisely the same manner as does *Diplomystus*, and from the last-named genus it has not been possible to prove any separation at all. Smith Woodward[8] is, therefore, apparently justified in claiming *Hyperlophus* to be a synonym of *Diplomystus*, although Dr. Jordan,[9] without arguing the question, has expressed a contrary opinion, saying: " Dr. Woodward regards *Hyperlophus* as a synonym of *Diplomystus*, which is quite unlikely. One may be too hasty in regarding living forms as identical with extinct genera, as well as too hasty in separating them."

So much, then, for the general facts of distribution. It is now in order to present a description of the new species of *Diplomystus* from a supposed early Tertiary horizon at Benito, on the western coast of tropical Africa.

Diplomystus goodi, sp. nov.

A deep-bodied species of moderate size, attaining a total length of about 15 cm., and resembling *D. longicostatus* (from South America) in that the caudal region is comparatively short and tapering. Dorsal region much elevated, the margin rising to the origin of the dorsal fin, behind which it abruptly descends; frontal profile steep. Maximum depth of the trunk equaling twice the length of the head with opercular apparatus. Abdominal vertebræ about sixteen in number, caudals not more than twelve or thirteen.

Pectoral fins small, and the much smaller pelvic pair opposed to the middle of the dorsal; the latter fin with about fifteen rays, and situated as in *D. longicostatus;* anal fin with about ten rays, arising considerably behind the posterior end of the dorsal. Ventral ridge-scales comparatively small in advance of the pelvic fins, but much larger beyond

[7] Ogilby, J. Douglas, In Records of the Australian Museum, Vol. II, 1892, p. 24.

[8] Woodward, A. S., Doubly-armoured Herrings. *Ann. Mag. Nat. Hist.* (6), Vol. X, p. 412.

[9] Jordan, D. S., Description of a Collection of Fossil Fishes from the Bituminous Shales at Riacho Doce, State of Alagôas, Brazil. ANNALS CAR. MUS., Vol. VII, No. 1, 1910, p. 25.

the pelvic fins, all smooth, and with only one spiniform projection, without serrations. Neural spines in advance of the dorsal fin with broad antero-lateral expansions, as in the type species. Scales of the flank thin, in most cases poorly preserved.

This species is represented in the collection by a number of more or less incomplete individuals, the better preserved of which are shown slightly reduced in size in Plates XXIII and XXIV, fig. 2. A composite drawing or restoration has not been attempted, but it is evident that an understanding of all the characters can only be gained by a synthesis of details exhibited by a number of fragmentary specimens. One must also be careful not to be misled by deceptive appearances, due to accident, or conditions of preservation. For instance, owing to weathering, or the effects of chemical action, the number of ribs and fin-rays sometimes appears to be larger than is natural, they having been split up. This condition is faithfully represented in respect to the dorsal fin-rays and anterior neural spines of the specimen shown in Plate XXIII, fig. 1. A similar splitting of the ribs, hæmal spines, and fin-supports is often observable in fishes from the Green River shales and elsewhere.

Diplomystus sp. ind.

A second Clupeoid species, probably of *Diplomystus*, but much smaller than that already described and of inferior preservation, is indicated by a number of crushed and otherwise distorted individuals, the total length of which does not exceed five or six centimeters. Very likely they are the fry of some larger form at present unknown, but differing from *D. goodi* in the lesser depth of the abdominal region. Their present condition does not, however, permit anything like an adequate description.

The manner in which the outline of the body is deformed in these fishes, a process which has sometimes been called "telescoping," suggests a slow current in the waters while sedimentation was in progress. Similar appearances are common in various Mesozoic and other horizons, especially in the Triassic sandstones of eastern North America, where the rock-making materials are supposed to have been laid down in shallow estuaries or brackish-water embayments partially cut off from the sea. It has not been thought worth while to illustrate these much dilapidated fish-remains.

Enchodus (?) sp.

A small-sized species which may be provisionally referred to this genus, but the precise relations of which cannot be determined with certainty, is indicated by the greater part of the caudal region and tail of a single individual, as shown in Plate XXIV, fig. 1. The form of body, as far as can be inferred from the portion preserved, is very similar to that of *E. longidens* (Pictet), from the Upper Cretaceous of Mount Lebanon, and it agrees also in size with the latter. The caudal fin in the African form is longer and more deeply furcate than in the Syrian species, and the dorsal fin is more remotely situated.

In the solitary specimen under examination more than a score of vertebræ are seen to be preserved in natural sequence, but it is impossible to tell whether these constitute the entire number of caudals, for the reason that the anal fin is not shown in its entirety. Of the dorsal only about ten of the widely spaced fin-supports, and the distal extremities of a few finely articulated fin-rays are to be seen. A few intermuscular bones are preserved above and below the axis, and the structure of the vertebral centra together with their spinous processes, and the relations of these latter to the median fin supports (interneurals and interhæmals) are in harmony with our determination of this species as belonging to the genus *Enchodus*, or to some closely related form. The remote position of the dorsal, its comparatively feeble fin-supports, and short caudal peduncle prevent an assignment of this species to the genus *Diplomystus*. The fact that *Enchodus* is an Upper Cretaceous genus must be granted some weight in ascribing the age of the fish-bearing beds at Benito to the early Tertiary.

We may conclude this paper with a few general remarks concerning *Diplomystus*, and other related doubly-armored herrings. True Clupeoids first appear at the beginning of the Cretaceous, and are probably descended from typical Jurassic Leptolepids, as indicated by their closely similar skeletal structure. The acquisition of enlarged ridge-scutes along the ventral margin, a character peculiar to *Clupea* and its allies, dates from the Lower Cretaceous, and toward the close of that period forms had become introduced and attained a wide distribution which possessed dorsal ridge-scutes as well as the ventral series. These are marine species, from Asia Minor, southern Europe, and Brazil, belonging to the genus *Diplomystus*. In North America a number of fresh-water species are found as early as the Middle Eocene.

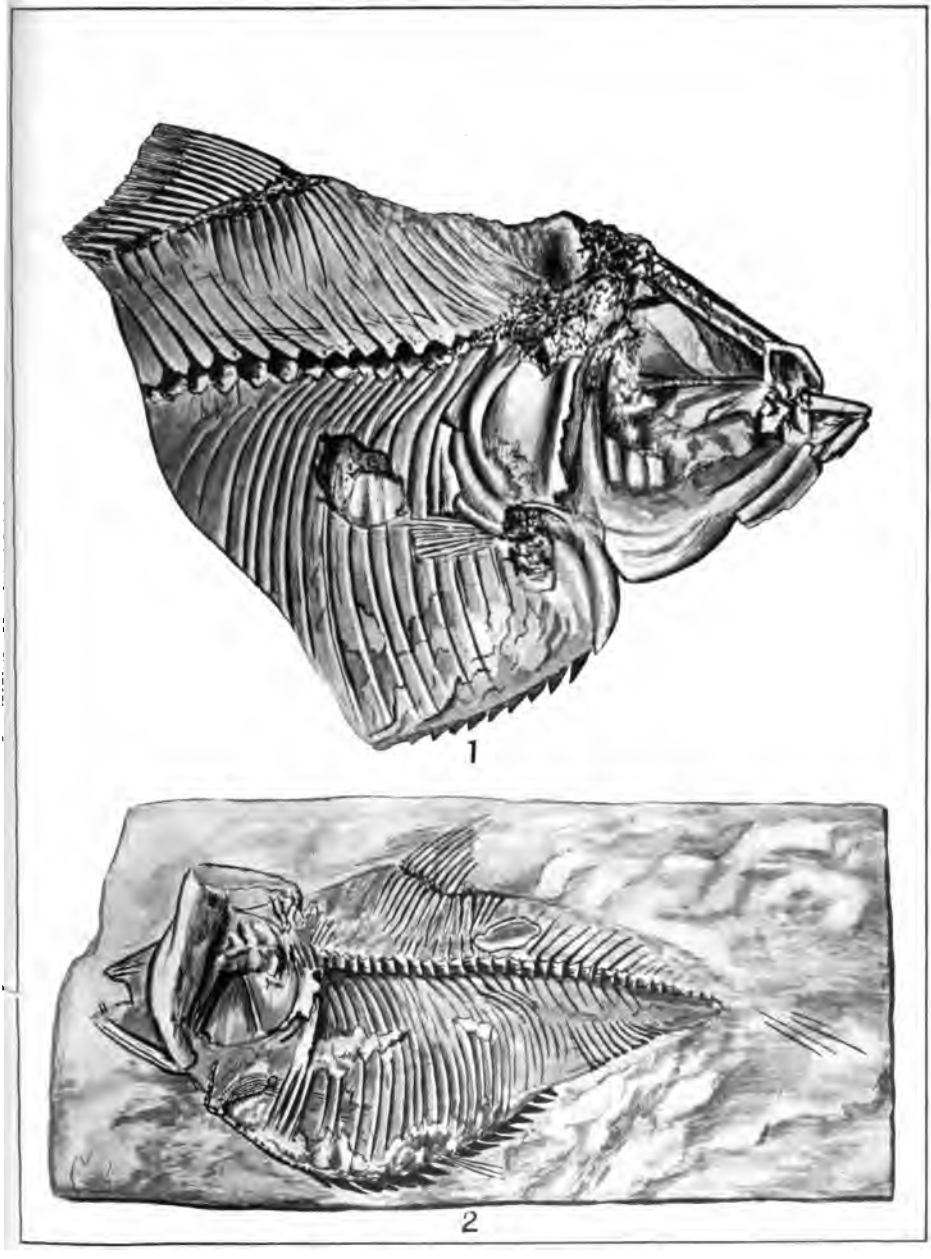
In South America and Africa related forms are known from supposed early Tertiary fresh-water strata, and at the present day the genus *Diplomystus* itself survives in the rivers of Chili and New South Wales.

The type-species *D. dentatus* Cope, and the scarcely separable *D. analis* and *D. pectorosus*, have the dorsal ridge-scutes broader than long, and finely denticulated at their posterior border. In species having a slenderer and more elongate form of body, like the so-called *D. humilis* and *D. altus* of Leidy, the dorsal scutes are narrow and simple, with one pointed projection. This distinction is considered by Jordan to be of generic, or at least subgeneric importance, and the two last-named species are transferred from *Diplomystus* proper to the closely related genus or subgenus *Knightia* of Jordan. The type species of "Knightia" is *K. eocæna* Jordan, = *Diplomystus pusillus* Cope, = *Clupea humilis* Leidy.

A second closely related genus or subgenus, named *Ellipes*, has recently been established by Jordan upon the evidence of Brazilian Clupeoids from late Cretaceous and supposed early Tertiary horizons. The type species is named *E. branneri*, a small fish presenting much the same configuration as the type of *Diplomystus;* and accompanying it in the same horizon is the so-called *E. riacensis*, which is slenderer and more elongate, and hence approaches *D. eocæna* (= "Knightia") in general aspect. In the opinion of Dr. Jordan, *D. longicostatus* Cope, from the Upper Cretaceous of Brazil, should also be classed under *Ellipes*, but from this view the present writer dissents. When one has to deal with material that in the main is of fragmentary nature, and when much inconstancy is to be observed among the characters recognized as having specific value, it seems advisable to hold to a broad conception of genera and families, and to avoid drawing distinctions of such narrow margin as to obscure natural relationships

EXPLANATION OF PLATES.

Pl. XXIII, Fig. 1. *Diplomystus goodi*, sp. nov. × 1/1.
Pl. XXIII, Fig. 2. *Diplomystus goodi*, sp. nov. × 5/4.
Pl. XXIV, Fig. 1. *Enchodus*, sp. ind. × 4/5.
Pl. XXIV, Fig. 2. *Diplomystus goodi*, sp. nov. × 1/1.



Diplomystus goodi Eastman, sp. nov.

Fig. 1 (type) × ½. C. M. Cat. Foss. Vert., No. 5250.
Fig. 2 (cotype) × ¾. C. M. Cat. Foss. Vert., No. 5253.

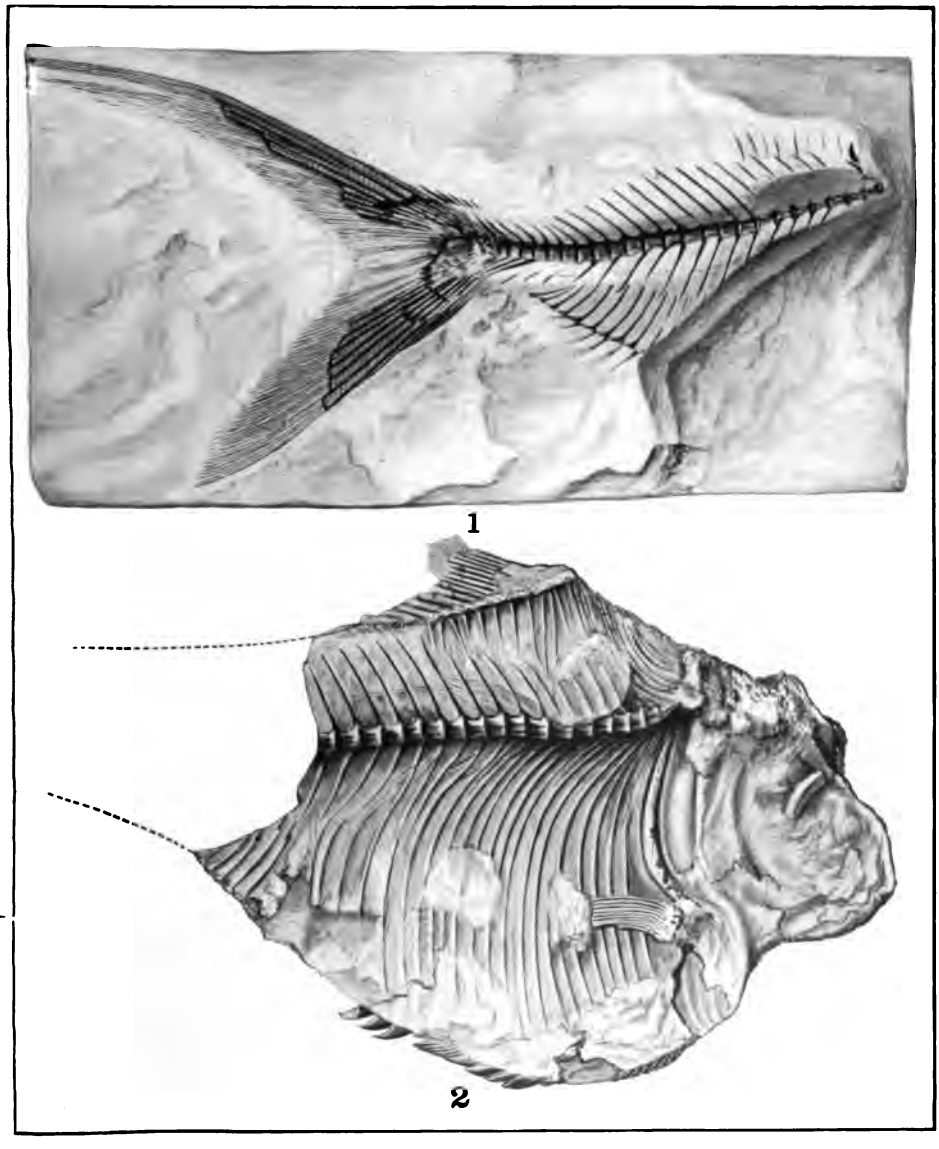


Fig. 1. *Enchodus* sp. ind. × ⅔. C. M. Cat. Foss. Vert., No. 5254.
Fig. 2. *Diplomystus goodi*, sp. nov. × ½. C. M. Cat. Foss. Vert., No. 5251.

[From The American Journal of Science, Vol. XXXV, April,

The OLIGOCENE of the ROANNE BASIN ITS VERTEBRATE FAUNA.

By Charles Depéret.

Translated by C. R. Eastman, Carnegie Museum.

Art. XXXI.—*The Oligocene of the Roanne Basin and Its Vertebrate Fauna;** by Charles Depéret.

As shown by the studies of Le Verrier, the Tertiary basin of the Roannais (a former province near Lyons, France) comprises a basal series of sands, gravels and clays, supposed to be of Stampian age, and an upper series of calcareous marls corresponding to the Aquitanian, the whole being practically barren of fossils.

During recent years important paleontological discoveries have been made in consequence of the extension of the earthenware industry in the vicinity of Mayolet, Briennon, Mably, and especially La Bénissons-Dieu. For the purpose of arriving at a more precise correlation of these deposits a reinvestigation has been made by the present writer of the Oligocene strata as they occur in the Roanne basin, where they form a monocline dipping toward the northwest, and present the following section (arranged in ascending order):

4. Calcareous marls of Saint-Germain-Lespinasse, extending between that place and Digoin, and yielding at the latter locality remains of an *Anthracotherium* characterized by having digits of sub-equal length, and apparently belonging to the same species as that which occurs at La Bénissons-Dieu.

3. Strata of Mably and La Bénissons-Dieu, consisting of a bottom bed of sands, which graduates upward into clays. From the latter of these two localities have been obtained excellently preserved remains (including the entire cranium, jaws, limbs, etc.) of a large *Anthracotherium*, the lateral digits of which are much less reduced than in *A. magnum* (= *A.* cf. *bumbachense* Stehlin). There have also been found here two species of *Aceratherium*, one of which is very large (*A. filholi* Osborn), the other very small (*A. albigense* Roman); and besides these there occur remains of a species of *Cainotherium*, one of *Dremotherium*, as well as Crocodiles and Chelonians.

2. Reddish clays of Briennon. These have yielded at Briennon remains of *Entelodon magnum* Aymard, and at Mayolet an inferior molar of the small *Anthracotherium alsaticum* Cuvier.

1. Nonfossiliferous bands of gravels, sands and conglomerates.

The strata constituting the above section may be correlated as follows: Divisions 1 and 2 are referable to the Sannoisian (Lower Oligocene), the few known fossil forms being identical with those occurring in the Lower Oligocene asphalt deposits of Lobsann, in Alsace. Division 3, or the strata of Mably and La Bénissons-Dieu, corresponds to the lower portion of the

* A preliminary notice, to be followed by a more detailed article in the Bulletin de la Société Géologique de France. Translated by C. R. Eastman, Carnegie Museum, Pittsburgh, Penn.

Stampian (Upper Oligocene), being well characterized by the above-named species of *Aceratherium*. The fourth member of the series, or marly limestone of Digoin, carries the same species of *Anthracotherium* as Division 3, and cannot be younger than of Middle Stampian age. There are no strata, therefore, in the Roanne basin that can be properly referred to the Aquitanian (or Lower Miocene), as has formerly been thought.

Postscriptum added by the Translator.

As a result of Professor Depéret's determination of the vertical succession of Tertiary strata in the Roannais, Lyonnais, and adjacent regions, it is now possible to synchronize more precisely than was formerly the case the different mammiferous horizons throughout various parts of France and elsewhere. One may compare, for instance, the tabulation given above with the following arrangement of mid-Tertiary beds in the Paris Basin, which is adopted by Paul Lemoine in his recent work, La Géologie du Bassin de Paris (1911):

MIOCENE.	
Tortonian	Faluns de l'Anjou.
	Faluns de Touraine.
Helvetian	Sables de Sologne.
Burdigalian	Sables de l'Orléannais.
Aquitanian	Calcaires de l'Orléannais.
OLIGOCENE.	
Chattian	Meulières de Montmorency.
Stampian	Sables de Fontainebleau.
Sannoisian	Calcaire de Brie.

The general correspondence of these time divisions and depositions with North American formations will appear from the table appended below, which has been drawn up by Mr. O. A. Peterson, of the Carnegie Museum, from the most recent data available, including the results of his own field studies and those of the late Mr. Hatcher:

In South Dakota, as is well known, the Oligocene is much more extensively developed than in the Nebraska region, and comprises three clearly marked faunal zones, which have been named as follows: (1) Titanotherium beds (= Lower White River or Chadron beds); (2) Oreodon and Metamynodon beds (= Middle White River); and (3) Leptauchenia and Protoceras beds (= Upper White River). The middle and upper members of the White River are grouped together by some geologists under the term of Brule formation, which attains a maximum thickness of about 400 feet, or about double that of the lower member (= Chadron or Titanotherium beds). In

Table of Mid-Tertiary Correlatives.

European Stages	Nebraska Section	John Day Basin
Upper and Middle Miocene	Upper Harrison beds	Mascall formation and Columbia Lava
	Lower Harrison beds	[Interval of erosion]
Lower Miocene (Aquitanian)	Monroe Creek beds Gering sandstone	Upper John Day beds Middle John Day beds
Upper Oligocene (Stampian) Lower Oligocene (Sannoisian)	Leptauchenia beds and underlying Oligocene strata (Chadron beds and Brule formation), of much less thickness than the equivalent White River beds of the South Dakota section.	Lower John Day beds, transitional between Oligocene and Miocene, of continuous deposition with the Middle John Day beds, and resting unconformably upon the Clarno beds of undoubted Eocene age.

South Dakota, also, the Lower Miocene falls naturally into a two-fold instead of a tripartite division as in Nebraska, the two members of the series being known as the Lower and Upper Rosebud beds. The Lower John Day beds of Oregon are of transitional character, and may be classed as either uppermost Oligocene or lowermost Miocene, the difficulty being that they are not separated from the Middle John Day beds by any apparent stratigraphic break.

An earlier and somewhat different correlation of the section in the John Day Basin than that which is here proposed by Mr. Peterson will be found in an article by Drs. J. C. Merriam and W. J. Sinclair on the Tertiary Faunas of the John Day Region (Bull. Dept. Geol. Univ. Cal., 1907, vol. v, No. 11). For the benefit of those interested in the correlation of European formations reference may be made to the following recent papers :

Dollfus, G. F.; Essai sur l'Étage Aquitanien. Bull. Serv. Carte Géol. France, 1910, vol. xix, no. 124. [The Aquitanian is here considered as Lower Miocene.]

Stehlin, H. G.; Remarques sur les faunules de mammifères des couches éocènes et oligocènes du Bassin du Paris. Bull. Soc. Géol. France, 1912, (4) vol. ix. See also his Revision of European Anthracotheres, 1910.

Glangeaud, P.; Les faciès de l'Oligocène aux environs de Bergerac et dans le Dordogne, 1912, loc. cit.

Haug, E.; La Période Néogène, in his 'Traité de Géologie,' 1911, vol. ii, fasc. 3.

Perisho, E. C., and *Visher, S. S.;* South Dakota Geol. Surv., 1912, Bull. No. 5.

DIPTERUS REMAINS FROM THE UPPER DEVONIAN OF COLORADO.

By C. R. Eastman.

(Issued June 1, 1915.)

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XVII. DIPTERUS REMAINS FROM THE UPPER DEVONIAN OF COLORADO.*

BY C. R. EASTMAN.

The first announcement that strata of Devonian age occur in the San Juan region of Colorado was made by F. B. Meek[1] more than three decades ago, after an examination of some invertebrate fossils collected by F. M. Endlich of the Hayden Survey during the summer of 1874. A few fish remains were also obtained from the same beds by Endlich, who remarks upon their occurrence as follows: "Besides these, scales and fragments of bones are found, belonging to some fish of considerable size. Too little material could be collected to admit of any identification, even only generically. Small scutellæ also occur, probably belonging to the same animal."[2]

During the more recent survey of the San Juan country under the direction of Dr. Whitman Cross large collections were made from the two formations which have been found to carry Devonian fossils in southwestern Colorado, and the extensive faunas that have been brought to light from the Upper Devonian and Lower Carboniferous of this State are now satisfactorily known, thanks more especially to the studies of G. H. Girty.[3]

The limestone formation from which Devonian fossils were first obtained by Endlich is known as the Ouray limestone, this term having been proposed by A. C. Spencer[4] in 1900. It yields over thirty species of invertebrates and one species of fish, the latter described by O. P. Hay[5] under the name of *Cladodus formosus*. In the words of Dr. Whitman Cross,[6] "the position of the Ouray lime-

* Published by the permission of the Director of the U. S. Geological Survey.

[1] Bull. U. S. Geol. and Geog. Survey, 2d Ser., no. 1, 1875, p. 46.

[2] Ann. Rep. U. S. Geol. and Geog. Survey for 1874, pp. 211–214.

[3] Devonian Fossils from Colorado. The Fauna of the Ouray Limestones U. S. Geol. Survey, 20th Ann. Rep., pt. II, 1900, pp. 25–81.—The Carboniferous Formations and Faunas of Colorado. Professional Paper No. 16, U. S. Geol. Survey, 1903.

[4] "Devonian Strata in Colorado," *Amer. Jour. Sci.* [4], Vol. IX, 1900, p. 125.

[5] "Description of a New Species of Cladodus, etc.," *Amer. Geol.*, Vol. XXX, 1903, pp. 373–4. It is suggested in his paper that the age of the Ouray limestone may be late Middle or early Upper Devonian.

[6] "A New Devonian Formation in Colorado," *Amer. Jour. Sci.* [4], Vol. XVIII, 1904, p. 246.

stone as a well determined unit of the Paleozoic section of Colorado must be considered as well established." It is adjudged by the authority just quoted that the formation in question is of uppermost Devonian age, but the fauna which it contains is but distantly related to those of the New York area, or even to the more western Devonian faunas of this country. It is, on the other hand, "somewhat strikingly similar to the Devonian of Russia."

The Ouray limestone, with a thickness ranging from 100 to 250 feet in the San Juan country, rests conformably upon strata a hundred feet or so in thickness, which Dr. Cross has named the *Elbert formation*, and in the opinion of this geologist the strata so designated "seem unquestionably to form a lithologic, stratigraphic and faunal unit." Intervening between the Elbert formation and the basal granite of the region are beds of quartzite, supposed to be of Upper Cambrian age.

So much for the general Palæozoic section of the San Juan region. The stratigraphic equivalence of the Elbert formation is shown by the evidence of its fish-remains, the only fossils yet obtained from it, to be with the so-called "Parting Quartzite" of Leadville, in central Colorado, and of Aspen, on the northeastern flank of the Elk mountains; and the general aspect of these fish-remains has been pointed out by the present writer to be indicative of Upper Devonian age.[7] Nevertheless, the ichthyic fauna of the Elbert was recognized as not being closely similar to the faunas of the eastern and central United States, in this respect agreeing with the Ouray invertebrate fossils, which Dr. Girty has shown to "exhibit a closer parallel with the Devonian of the Ural Mountains."

The fish-remains thus far brought to light from the Elbert formation in Colorado, although numerically abundant, present a singular lack of systematic diversity. Arthrodires are represented by dissociated tuberculated plates belonging to a fish about twice the size of the type species of *Coccosteus*, but whose precise relations are not determinable. Besides these fragments, only four recognizable species have been thus far identified, as follows: *Bothriolepis coloradensis*, *B. nitida*,[8] *Holoptychius giganteus*, and *H. tuberculatus*. The second, third and fourth of the species just named occur typically

[7] "On Upper Devonian Fish Remains from Colorado," *Amer. Jour. Sci.*, Vol. XVIII, 1904, p. 260.

[8] This name antedates that of *B. leidyi*, which is synonymous with it.

in the Catskill of Pennsylvania, and the nearer affinities of *B. coloradensis* appear to be with certain Scottish Old Red Sandstone forms.

Only a few of the remains collected by Messrs. Spurr and Tower from the fish-bearing locality at Aspen, in central Colorado, have come under the writer's inspection. It seems to be certain, however, that Arthrodiran fragments and teeth of Holoptychius or some allied Crossopterygian occur, and the presence of Dipnoans was suspected on account of "certain smooth scales displaying their characteristic perforations." Concerning these latter it was remarked by the writer in 1904 that the remains "are noteworthy for furnishing the only indication we possess at present of the occurrence of Lung-fishes in the Colorado Devonian." No evidence had at that date been obtained which might suggest a relationship between the fauna of the Colorado Devonian and that of the west central states, and the absence of Ptyctodont tritors and Dipnoan teeth, such as constitute a so well-marked feature of the Upper Devonian of Iowa, was regarded as somewhat surprising.

Owing to the insufficient evidence on the paleontological side, it was impossible in 1904 for Dr. Cross or the present writer to reach altogether satisfactory conclusions as regards the stratigraphic equivalence of the Colorado Devonian. The former writes in his article already referred to for that year:

"While certain correlations for both the Elbert and Ouray formations seem definitely indicated by present knowledge, meagre as it is in some directions, there is a marked contrast between the lower Palæozoic section of western Colorado and that of the Front range, especially as exhibited near Canyon City."

Likewise Eastman, at the close of his article accompanying that of Dr. Cross:

"For the present, the question as to the origin of the vertebrate fauna of the Colorado Devonian must be considered as problematical, and one which will require considerable further evidence and investigation before it can be answered satisfactorily. It is evident that the remains thus far obtained . . . open up problems of distribution, and others of a geological nature, which are worthy of careful study."

Thus the problem stood eleven years ago. Thanks to the continued interest and activity of Dr. Cross, valuable new information has recently been acquired which bears upon the homotaxial relations

of the Elbert formation. Briefly, the new data consist in the discovery of a small number of extremely characteristic Dipnoan remains—Dipterine and Synthetodont teeth—which have been heretofore known from but a single horizon and locality, namely the Upper Devonian State Quarry beds of Johnson County, Iowa. Illustrations are given in the accompanying text-figure of several of these teeth, all of which were obtained by Dr. Cross in July, 1909, from the Elbert formation of Florida Valley, east side, in the Ignacio Quadrangle of southwestern Colorado. The originals of these figures are preserved in the United States National Museum.

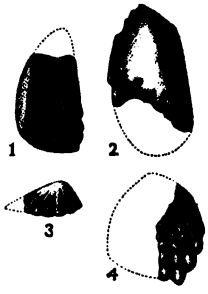
The specific identity of the *Dipterus* remains admits of not the least particle of doubt, the following forms being easily recognizable: *D. mordax*, *D. pectinatus*, and *D. digitatus*. The Synthetodont type of crushing plate (Fig. 1) is probably new, but is left unnamed for the present, or until such time as further material is available for preparing a satisfactory diagnosis. One cannot be altogether certain in the case of the unique specimen shown in the figure whether we have to do with a single complete dental plate, or with one of the halves of a composite pavement, such as we are familiar with in the type species of *Synthetodus*.

Without entering into details it may be stated that the evidence afforded by the three above-named Dipterine species, and one undescribed *Synthetodus*-like type of dental plate, is sufficient for establishing a close correlation between the Elbert formation of Colorado and the Upper Devonian of the Cedar Valley region of Iowa. In addition, the occurrence of *Dipterus* scales in the fish-bearing beds at Aspen confirms the belief in a synchronism between those beds and the Elbert formation in the San Juan country. According to this correlation a somewhat later age must be assigned to the Ouray limestone than that which Drs. Hay and Girty have been willing to concede for it.[1]

That which in 1904 appeared difficult of comprehension was how certain characteristic species from the Chemung-Catskill of the Appalachian region should have transmigrated into the Cordilleran sea by way of the Dakotan, without admixture being found in the Colorado Devonian of western Upper Devonian forms of fish life; and it was suggested at that time that the Chemung-Catskill of the Colorado Devonian fauna must have come by another route than by the Dakota sea.

[1] *Amer. Geol.*, Vol. XXX, 1903, p. 373.

The recent discovery of Dipterine remains in the San Juan country happily simplifies the problem, and appears to prove that the line of communication between the Appalachian and Cordilleran regions during late Devonian times was actually by way of the Ohioan and Dakotan seas; also that interchange took place between the faunas of the Elbert formation and the so-called State Quarry beds of Iowa toward the close of the Devonian.



FIGS. 1–4. Dipnoan dental plates from the Upper Devonian of Colorado. 1, Synthetodont type of crushing plate. 2, *Dipterus digitatus* Eastm. 3, *Dipterus mordax* juv. Eastm. 3, *Dipterus peclinatus* Eastm. (All figures natural size.)

It is of some further interest to recall in this connection that the earliest reported occurrence of Dipterine remains in this country is that of a dental plate of *Dipterus* itself in the Columbus limestone of Ohio,[10] and that the only Elasmobranch species thus far described from the Colorado Devonian (*Cladodus formosus* Hay) bears a not altogether remote resemblance to *C. concinnus* from the Huron shale of Ohio.

[10] Bull. 10, 4th Series, Geol. Survey Ohio, 1909, p. 196, pl. xvii, figs. 14–17.

FOSSIL FISHES IN THE COLLECTION OF THE UNITED STATES NATIONAL MUSEUM

BY

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Of the American Museum of Natural History, New York City

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INTRODUCTION.

The collection of fossil fishes belonging to the United States National Museum, although not extensive, is a representative series, comprising characteristic species from all of the main geological time divisions from the Ordovician onward, and including about 170 type-specimens and other important material which has served in the description of species or determination of geological horizons. The greater part of the material was obtained under the auspices of the United States geological surveys and exploring expeditions, and a large quantity of fish remains was added to the collection through the acquisition of a number of important private collections, like those of Lesquereux, Lacoe, Sherwood, and others. Some foreign material, from various horizons, but chiefly Mesozoic and Tertiary, was acquired at different times by exchange or purchase.

Prior to the installation of the collection of fossil vertebrates in the new building of the United States National Museum the fishes had not been systematically studied, nor even fully accessible nor arranged, owing to lack of space accommodations; and until eight years ago no published list had been prepared of the important type-specimens it contains. In 1905, under the direction of Dr. George P. Merrill, a catalogue of the type specimens of fossil invertebrates, by Charles Schuchert and associates, was published by the museum, and two years later this was followed by a second part, including the type specimens of fossil vertebrates and fossil plants.[1] The second part of this Catalogue records a wealth of material upon which Leidy, Cope, and Marsh founded much of their early work in vertebrate paleontology.

[1] Catalogue of the type and figured specimens of Fossils, Minerals, Rocks and Ores, etc. Part 2. Fossil Vertebrates, Fossil Plants, etc. Bull. U. S. Nat. Mus., No. 53, pt. 2, 1907.

During the first half of the year 1914, in pursuance of arrangements made by Dr. Charles D. Walcott, the fossil fish remains in the United States National Museum were systematically arranged and put in order by the present writer, and a number of undescribed or scientifically interesting specimens were set aside for special study. The greater part of these were afterwards placed in the hands of Mr. R. Weber for the purpose of preparing suitable illustrations to accompany a report upon the collection, which is now printed in the following pages. To Dr. G. P. Merrill, head curator of geology, and to Mr. J.W. Gidley and Mr. C.W. Gilmore, of the Section of Vertebrate Paleontology, cordial thanks are returned for the enjoyment of many privileges and courtesies extended while the work of studying the collection was in progress.

A. ORDOVICIAN SYSTEM.

The earliest remains of vertebrate life anywhere found are those occurring at several Ordovician localities in Colorado, the Bighorn Mountains of Montana, and the Black Hills uplift of South Dakota. The longest and best known of these localities is Harding Quarry, a short distance west of Canon City, Colorado, where vast quantities of detached scales and other fragmentary hard parts of primitive fishes are contained in sandstone (now known as the Harding sandstone) usually correlated with the Lower Trenton of the eastern United States and Lower Bala of Wales. R. S. Bassler in his bibliographic index of American Ordovician and Silurian fossils places the Harding sandstone in the Black River groups because it underlies the Kinnswick limestone of uppermost Black River age.

Three species, supposed to represent true fishes, were established by Dr. C. D. Walcott,[1] after an examination of hundreds of fragments collected by himself and Dr. T. W. Stanton at Canon City in 1890 and 1891, and the ichthyic nature of the remains was confirmed by Dr. Otto Jaekel's study of microscopic sections of dermal plates belonging to two of the species.

Cope, however, in a review of Walcott's paper, expressed the opinion that it is "extremely unlikely that these forms are fishes, but they are more likely *Agnatha*." Under this latter term the author just quoted included the great extinct group of fishlike vertebrates to which he applied the name of Octracodermi, and to which he assigned a lower rank than that of Pisces proper.

[1] Walcott, C. D. Notes on the discovery of a vertebrate fauna in Silurian (Ordovician) strata. Bull. Geol. Soc. Amer., vol. 3, 1892, pp. 153–172. Doctor Jaekel's views as to the nature of the remains are appended to this article, and are again stated in a review published by him in Neues Jahrb. f. Mineral., 1895, p. 162. Cope's review is found in the American Naturalist for March 1893, pp. 268–269. See also the same journal for February, 1891, p. 137, for a notice of Doctor Walcott's first communication.

Influenced by the idea that some of the tuberculated dermal plates described by Doctor Walcott from the Canon City locality bore a strong resemblance to certain well-known Devonian fishes, such as *Coccosteus* and Asterolepids, the suggestion has been put forward by some writers that the fish beds at Canon City are probably not of Ordovician but of Devonian age. The suggestion appears untenable in view of the fact that the accompanying invertebrate fauna, represented by more than thirty species, exhibits clearly the facies of the Middle Ordovician limestone of New York and the Mississippi Valley. The same invertebrate fauna persists upward to a horizon 180 feet above the fish beds, and includes a number of highly characteristic forms, such as *Receptaculites oweni* and various molluscous and crustacean species. An excellent account of this and the corresponding section in Wyoming was published by N. H. Darton [1] in 1907, and two years later the same author [2] announced the discovery of fish remains in the Ordovician near Rapid City, South Dakota.

Still more recently, in 1913, the discovery was announced by T. D. A. Cockerell [3] of another locality in Colorado, near Ohio City, at which fish-remains occur similar to those found at Canon City, and accompanied by the same invertebrate fauna. Professor Cockerell is impressed by the extraordianry resemblance that the fish remains from the Ohio City locality bear to well-known types of Devonian fishes, and claims to have found representatives of three families, Diplacanthidae, Holoptychiidae, and Coccosteidae. These determinations are admitted, however, to be merely approximate, and can only be accepted in a provisional sense until the material has been carefully investigated. The Ordovician age of the containing beds seems to be conclusively established by the evidence of invertebrate remains.

OSTRACODERMI.

ASTRASPIDAE, new family.

An imperfectly definable family, known only by a single genus, *Astraspis*, which has the large median dorsal and ventral plates of the body armor constructed in the same fashion as in the Psammosteidae, out of fused polygonal tesserae, and the external ornament of these plates also similar in a general way to that observed in various genera of Heterostracous Ostracoderms.

[1] Ordovician of the Bighorn Mountains. Bull. Geol. Soc. Amer., vol. 17, 1907, pp. 541–566.

[2] Discovery of fish remains in the Ordovician of the Black Hills, South Dakota. Bull. Geol. Soc. Amer., vol. 19, 1909, pp. 567–568.

[3] Cockerell, T. D. A. Ordovician (?) fish remains in Colorado. Amer. Naturalist, vol. 47, 1913, pp. 246–247.

Genus ASTRASPIS Walcott.

ASTRASPIS DESIDERATA Walcott.

Plate 12, figs. 5, 6.

Astraspis desiderata WALCOTT, Bull. Geol. Soc. Amer., vol. 3, 1892, p. 166, pl. 3, figs. 6–14; pl. 4, figs. 1–4.

The original specimens upon which this species was founded are preserved in the United States National Museum collection, and are catalogued under the number 2351. They consist of fragmentary plates, ornamented with a coarse tuberculation, and not sufficiently complete to permit of even ordinal determination. A suggestion was made, however, by the original author that the form was allied to Devonian Antiarchs like *Asterolepis ornata*.

Some months after the presentation of Doctor Walcott's paper before the Geological Society in 1891, and before it had been printed in the bulletin, a unique and extremely important specimen of *Astrapis* was discovered at the type locality, and a brief description of it was given by Doctor Walcott in a footnote dated March, 1892, added to page 167 of his paper. This specimen is now preserved in the Museum collection (Cat. No. 8121) and is illustrated for the first time in the accompanying plate 12, figure 6. Preserved in the form of an impression of the outer surface, a plaster cast taken from the natural mold is shown in figure 5 of the same plate.

The later discovered specimen shows a structural characteristic which the earlier known fragments failed to disclose, namely, that the large element, or shield, is of compound nature, being made up of a large number of small polygonal tesserae in precisely the same manner as in Cephalaspids and Psammosteids. Moreover, the style of ornamentation is similar to that observed in the families just named, each of the small polygonal tesserae rising into a conspicuous central prominence which is surrounded by numerous minute stellate tubercles. The compound nature of the shield was recognized by Walcott, and the tuberculated ornament was compared by him with the somewhat similar features displayed in *Thyestes verrucosus* Eichwald, in which the larger tubercles are disposed in several longitudinal rows. Influenced by this consideration, and also by a resemblance in general outline, Walcott reached the conclusion that *Astraspis* was related on the one hand to "cephalaspidian fishes of the Silurian of Russia," and on the other to "Asterolepidae of the lower Devonian." [1]

The large compound plate of *Astraspis* was homologized by Walcott with the head-shield of Cephalaspids, although it fails to exhibit any trace of orbits and other prominences characteristic of that group or of other members of the Aspidocephalous order of Ostracoderms. Because these features are lacking in the impression of the plate be-

[1] Bull. Geol. Soc. Amer., vol. 3, 1892, p. 167.

fore us, we should prefer to compare it with the large dorsomedian shield of *Psammosteus* and *Drepanaspis*, more particularly with such forms as *Psammosteus taylori* Traquair, from the Scottish Old Red Sandstone, and the Russian *P. paradoxus*. For an account of the structure of the shield in the two last-named species we may refer to recent papers by Traquair, Woodward, and Preobrajensky in which the organization of Psammosteus is described.[1]

The large compound plate of *Astraspis* differs from the dorsomedian and ventromedian shields of known Psammosteidae not only in outline, so far as may be judged from the portion preserved, but also in the presence of a median and two lateral ridges, which extend over the anterior half of the plate in a longitudinal direction. The outermost of these folds is apparently very close to and parallel with the external margin of the plate. The ridges in question recall somewhat the rows of enlarged tubercles seen in the head-shield of *Thyestes* and *Trematapis*. Owing to their presence, and to the peculiar form of the shield, which resembles somewhat a dorsomedian plate of *Coccosteus*, it seems necessary to place the genus *Astraspis* in an independent family, closely allied to the Psammosteidae. Some further remarks on the genus *Psammosteus* will be found under the caption of Silurian fishes.

Formation and locality.—Hastings sandstone, Black River group; Canon City.

B. SILURIAN SYSTEM.

Family PTERASPIDAE Smith Woodward.

Genus PALAEASPIS Claypole.

PALAEASPIS AMERICANA Claypole.

Palaeaspis americana CLAYPOLE, Amer. Naturalist, vol. 18, 1884, p. 1224.
Palaeaspis bitruncata CLAYPOLE, Amer. Naturalist, vol. 18, 1884, p. 1224.
Palaeaspis elliptica CLAYPOLE, Proc. Amer. Assoc. Adv. Sci., 1885, p. 426.

This species is represented in the collection by a number of fragmentary remains, none of which adds to our knowledge of the structural organization. It deserves to be recalled, however, that the reported presence of paired appendages in this species has been disproved by Dr. Bashford Dean, his investigation of the type material having shown that the structures regarded as such by the original describer are in reality Elasmobranch spines resembling *Onchus*, which have become accidently associated with the dermal shields of *Palaeaspis*. The dorsal shield consists apparently of a single plate,

[1] Traquair, R. H. Additional notes on the fossil fishes of the Upper Old Red Sandstone of the Moray Firth Area. Proc. Roy. Phys. Soc. Edinb., vol. 13, 1897, p. 379. Woodward, A. S. On the Upper Devonian Ostracoderm, Psammosteus taylori. Ann. Mag. Nat. Hist., ser. 8, vol. 8, 1911, pp. 648-652. Preobrajensky, J. A. Ueber einige Vertreter der Familie Psammosteidae Ag. Sitzber. Naturforsch. Gesellsch-Univ. Dorpat, vol. 19, 1910, pp. 21-36. (Text in Russian.)

and differs from that of *Pteraspis* [1] in lacking a posterior median spine. So far as at present known, the genus is monotypic, and limited to the Salina beds (Cayugan or "Neontaric") of the New York State geological survey scheme of classification. Dr. O. P. Hay is in error in citing this genus as occuring in the Onondaga stage of the Devonian.

C. DEVONIAN SYSTEM.

Family ASTEROLEPIDAE Traquair.

Genus BOTHRIOLEPIS Eichwald.

BOTHRIOLEPIS COLORADENSIS Eastman.

Bothriolepis coloradensis EASTMAN, Amer. Journ. Sci., vol. 18, 1904, p. 254, text figs. 2, 4.

The type material upon which this, the largest known American species of the genus, was founded, is now preserved in the collection of the National Museum. It was collected, together with a quantity of other Devonian fish-remains, by Dr. Whitman Cross in 1903, from the Elbert formation of Rockwood and Devon Point in southwestern Colorado. The occurrence is interesting on account of demonstrating the widespread distribution of the genus in Upper Devonian time, and also because it is difficult to trace a route of migration which would connect this species with its nearest ally in the western hemisphere, *B. canadensis* Whiteaves, from Scaumenac Bay in the Province of Quebec, Canada.

BOTHRIOLEPIS NITIDA (Leidy).

Stenacanthus nitidus LEIDY, Proc. Acad. Nat. Sci., Phila., vol. 8, 1856, p. 11, and Journal, ser. 2, vol. 3, p. 164, pl. 16, figs. 7, 8.

Holonema rugosa COPE (*errore*), Proc. U. S. Nat. Mus., vol. 14, 1891, p. 456, pl. 30, fig. 7.

This species, known only by fragmentary portions of the dermal armor and appendages, occurs abundantly in the Catskill sandstone along the border line between New York and Pennsylvania. Numerous specimens belonging to this form are contained in the Sherwood and Lacoe collections, now the property of the United States National Museum. One specimen in the Lacoe collection calls for special notice, for the reason that it was figured and described by Cope as a pectoral limb of the genus *Holonema*. It is from the Catskill of Mansfield, Tioga County, Pennsylvania, and bears the catalogue number 1981. H. S. Williams, in 1893, first recognized it as an appendage of *Bothriolepis*, but erroneously referred it to *B. canadensis*.

[1] Important new light on the structure of this genus is contained in a paper by F. Drevermann, Ueber *Pteraspis dunensis*, published in Zeitschr. Deutsch. Geol. Gesell., vol. 56, 1904, pp. 275–289. It is noticed by Gaskell in his Origin of the Vertebrates, London, 1908. See also the following by Johann Kiaer: A new Downtonian fauna in the sandstone series of the Kristiania area. Vid.-Selsk. Skrifter, Kristiania, 1911, No. 7, pp. 5–22.

Family PSAMMOSTEIDAE Traquair.

Genus PSAMMOSTEUS Agassiz.

Syn. *Placosteus* and *Psammolepis* Agassiz; *Dyptychosteus* Preobrajensky.

This genus is represented in the United States National Museum collection by a few fragmentary remains from the Devonian of northwest Russia, received through the School of Mines at St. Petersburg. Until about a score of years ago little was known concerning the skeletal organization of the primitive chordates belonging to this and related genera, and competent authorities assigned *Psammosteus* to a position among the Elasmobranchs. In October, 1894, however, Dr. R. H. Traquair [1] published a description of a new species of *Psammosteus*, named by him *P. taylori*, from the Upper Old Red Sandstone of the Elgin district, Scotland, and in the light of his subsequent discovery of nearly complete specimens of *Drepanaspis* in the Lower Devonian of Germany, the Scottish author [2] suggested that *Psammosteus* should be placed in close association with *Drepanaspis* in the Heterostracous section of the Ostracodermi. Some further details concerning the body armor of *P. taylori* were made known by Dr. A. Smith Woodward [3] in 1911, the result of which was to confirm Doctor Traquair's reference of the genus to the Ostracoderms.

About the time when *Psammosteus* was first discovered in Scotland, in 1895, a brief notice of the various plates and spines of the same genus which are preserved in the Museum of the University of Dorpat was published by Dr. A. S. Woodward,[4] who had examined the remains three years previously, and in this article a figure was given of a dorsomedian shield of *P. paradoxus* Agassiz, from the Upper Devonian of Neuhausen, Livonia. A copy of Woodward's illustration of this plate is shown in the accompanying text-figure 1; and the reason for our noticing it thus particularly is because the identical specimen was again figured in 1910, by a Russian geologist who had evidently overlooked the earlier writings of Traquair and Smith Woodward, and proposed to establish a new genus and species upon the evidence of the plate in question.

In this paper by Doctor Preobrajensky,[5] the text of which is in Russian, the question of nomenclature is still further complicated by

[1] Ann. Scott. Nat. Hist., vol. 3, 1894, p. 225; also The Extinct Vertebrata of the Moray Firth Area, in Brown and Buckley's Vert. Fauna Moray Basin, 1896, pp. 260-263.

[2] Traquair, R. H. Report on fossil fishes . . . from the Silurian rocks of the South of Scotland. Trans. Roy. Soc. Edinb., vol. 39, 1899, p. 848.

[3] Woodward, A. S. On the Upper Devonian Ostracoderm, Psammosteus taylori. Ann. Mag. Nat. Hist., ser. 8, vol. 8, 1911, pp. 648-652.

[4] Woodward, A. S. The problem of the primaeval Sharks. Natural Sci., vol. 6, 1895, pp. 38-43, fig. 1.

[5] Preobrajensky, J. A. Ueber einige Vertreter der Familie der Psammosteidae Ag. Sitzber. Naturforsch. Gesell. Univ. Dorpat, vol. 19, 1910, pp. 21-36. pl. 2.

the fact that the type-species of the supposed new genus "*Dyptychosteus*" is named *tesselatus*, a title under which another species of *Psammosteus* had been previously described by Traquair.[1] If at some future time the Dorpat plate should be proved to be distinct from *Psammosteus paradoxus*, a new specific designation must be applied to it. For the present, however, we prefer to regard the term "*Dyptychosteus tesselatus*" as a synonym of *P. paradoxus*. Also, as far as one may judge from the published figure of the plate called by the Dorpat author *Psammosteus imperfectus*, this would appear to be one of the dorsomedian plates of *Ceraspis carinata* Schlüter.

FIG. 1.—DORSOMEDIAN SHIELD OF PSAMMOSTEUS PARADOXUS AGASSIZ, WANTING SUPERFICIAL ORNAMENTATION. UPPER DEVONIAN, NEUHAUSEN, LIVONIA. (AFTER A. S. WOODWARD AND PREOBRAJENSKY.)

The type material upon which the last-named species was founded is now preserved in the Museum of Comparative Zoology at Cambridge, Mass. A side view of one of the dorsomedian plates of this form is shown in plate 11, figure 1.

HOLOCEPHALI.

Family PTYCTODONTIDAE Smith Woodward.

The typical genus of this family, *Ptyctodus*, which is at the same time the most abundant and widely distributed of any belonging in the same association, was established by Pander in 1858, upon the evidence of detached "teeth," or tritors as they are more properly called, found in the Middle Devonian of the Governments of St. Petersburg, Novgorod, and the Russian Baltic Sea provinces. In the National Museum collection are contained a number of interesting fish-remains from these localities in northwestern Russia, and also from the vicinity of Dorpat. These consist of *Ptyctodus* tritors (from Babino, Novgorod), *Dendrodus*, *Holoptychinus*, *Psammosteus*, and

[1] Proc. Roy. Phys. Soc. Edinb., vol. 13, 1897, p. 377, pl. 11, figs. 1, 2.

for the most part fragmentary and dissociated plates of Asterolepids. The records show that a small but characteristic assortment of Russian Devonian fishes was received in exchange from the School of Mines at St. Petersburg many years ago. Some well-preserved Ptyctodont dental plates from the Upper Devonian of Iowa (State quarry beds) are also contained in the collection.

The Ptyctodont type of dentition agrees so closely with that of modern Chimaeroids that the opinion has been generally held, until recently at least, the forms of Devonian fishes possessing these characteristic dental plates must have been similar in their organization to modern Holocephali, and should be provisionally included in the same subclass. The view as to the relationships of Ptyctodontidae which has commonly prevailed up until about the year 1906 is well stated by Dean in his monograph on Chimaeroids, published by the Carnegie Institution of Washington.[1]

The passage reads:

> The main virtue in the study of Ptyctodontids is to the writer this, that they present some evidence (1) that Chimaeroids are of Devonian stock; (2) that at this early period their dental plates were still but four in number, representing the dental structure of the jaw-halves of sharks; and (3) that the tritors existed as small points forming together a texture in the dental plates which is well known among early sharks.

In the same year (July, 1906) a totally different conception of Ptyctodont relationships was advanced by Dr. Otto Jaekel, of Greifswald, who declared his belief that Ptyctodonts belong to the Chondrostean division of ganoid fishes, and that sturgeons themselves are related to "Placoderms" (*i. e.*, Arthrodires *plus* Asterolepids). The reasons for advocating this novel view are not stated by the author, except that they resulted from his investigation of newly discovered Rhynchodont remains from the Upper Devonian of Wildungen, described by him under the preoccupied title of *Rhamphodus*.[2]

In the course of his investigation of the Wildungen fish-remains certain dermal plates having a characteristic form and tuberculated ornament were found, the like of which occur also in the Middle Devonian of Wisconsin, and recall the dermal ossifications of *Myriacanthus*. Jaekel, however, in his discussion of the Wildungen material published in July, 1906,[3] interprets these scale-like dermal structures as the elements of a primary, internally situated pectoral arch, and attempts a hypothetical reconstruction of the arch after the pattern

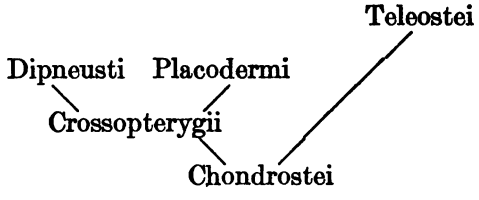
[1] Publication No. 32, 1906, p. 136.

[2] This generic name, with the type species of *Rhamphodus dispar*, was proposed by J. W. Davis in 1883 for certain Cochliodont teeth from the Lower Carboniferous limestone of Armagh. The dental plates upon which the so-called "*Rhamphodus tetrodon*" of Jaekel was founded are identical with the earlier described plates from the Eifel Devonian, known as *Rhynchodus major* Eastman. See Amer. Naturalist, vol. 32, 1898, p. 487; vol. 38, 1904, p. 296.

[3] Einige Beiträge zur Morphologie der ältesten Wirbeltiere. Sitzber. Ges. Naturforsch. Freunde Berlin, 1906, No. 7, pp. 180–189.

of the shoulder girdle in modern sturgeons. Impressed with the similarity which he observes between this conjectural arrangement and that presented by the body armoring of Arthrodires, he draws the inference that the latter group belong to the same stock as sturgeons. Apparently this view, together with the acceptance of Jaekel's reconstruction of a "shoulder-girdle" in Rhynchodus, influenced Dollo [1] to declare in favor of associating Ptyctodonts with Arthrodires.

It need only be said in this connection that the presence of an ossified pectoral arch in any genus of Ptcytodonts is an unconfirmed speculation very difficult to maintain in the lack of positive evidence; and the elements which have been interpreted as constituting it in a single genus are clearly of very different nature, being externally situated. And in case of any near affinity between Ptyctodonts and Arthrodires, we should expect the dental plates of the former to be accompanied by an ossified head-shield and other hard parts similar to those invariably associated with Arthrodires, which is precisely what we do not find in nature. The formerly prevalent view that Ptyctodonts are of Chimaeroid stock is in harmony with all the evidence thus far obtained. It may be of interest to introduce at this point a diagrammatic scheme taken from a paper by C. Tate Regan [2] for the purpose of showing graphically that author's ideas of the relationships of the sturgeons and "Placoderms" (*i. e.*, Arthrodires *plus* Antiarcha and Osteostraci, according to Regan's definition) to to the other orders of Teleostomes:



Genus HETERACANTHUS Newberry.

Syn. *Gamphacanthus* S. A. Miller.

This is a provisional genus, founded upon detached fin-spines occurring in the Middle Devonian of Wisconsin and adjoining states, the relationships of which are uncertain. Their association in the same beds with large dental plates of *Palaeomylus* and other Ptyctodonts affords reason for believing them to be of Chimaeroid nature, and for the present they may be tentatively referred to the family now under consideration.

[1] Dollo, L., Les Ptyctodontes sont des Arthrodères. Bull. Soc. Belge Géol., etc., vol. 27, 1907, pp. 1–12.
[2] The Phylogeny of the Teleostomi. Ann. Mag. Nat. Hist., ser. 7, vol. 13, 1904, pp. 329–349.

HETERACANTHUS UDDENI Lindahl.

Plate 1.

Heteracanthus uddeni LINDAHL, Journ. Cincinnati Soc. Nat. Hist., vol. 19, 1895 p. 95, pl. 6.

The spines of this species are less abundant than those of the coeval *H. politus*, which have a different general outline and a relatively coarse ornamentation. The type-specimen serving for the establishment of this species, now preserved in the Museum of the Cincinnati Society of Natural History, has the external surface partly denuded and is defective in preservation as regards the basal portion and anterior margin. Up to the present time, however, it has remained the most complete fin-spine of the species and genus thus far brought to light. During the past year a larger and still more perfect specimen has been found in the Cedar Valley limestone near Iowa City, Iowa, by Prof. Abram O. Thomas, of the State University, and placed in the writer's hands for study. It is shown of the natural size in plate 1.

The posterior or convex margin of the newly discovered spine is more strongly arched than in the type-specimen, and the distal portion is forwardly curved to a slight degree. On the other hand the anterior margin is not developed so strongly as to form a projecting shoulder toward the base, which is the case to a certain extent in the type-specimen, and in which respect an approach is indicated to the conditions observed in *Stethacanthus* and Lower Carboniferous species of *Oracanthus*. Nevertheless, the character of the ornamentation is practically identical with that of the original upon which the species is founded, and for that reason we are disinclined to regard the two spines as specifically distinct. In the specimen here figured, the entire outline of the inserted portion of the base is distinctly shown, and the resemblance of the inserted part to the base of Chimaeroid head-spines, and also those of Carboniferous forms like *Physonemus*, etc., is obvious. It is probable that the dermal defenses of this nature occupied a position immediately behind the head.

Formation and locality.—Cedar Valley limestone (Middle Devonian); Johnson county, Iowa.

DIPNOI.

Family CTENODONTIDAE Traquair.

Genus DIPTERUS Sedgwick and Murchison.

The earliest known occurrence of Dipterine remains in this country is that of a dental plate of *Dipterus* itself which has been described within the last few years from the Columbus limestone (Middle

Devonian) of Ohio.[1] Some half-dozen species, all of them founded on isolated teeth, are known from the Chemung-Catskill of New York and Pennsylvania, and great numbers are found in the Middle and Upper Devonian of Iowa. Although fish remains were reported from the Ouray limestone in the San Juan region of Colorado as long ago as 1874, and several species were brought to light by Dr. Whitman Cross in 1904, from the immediately underlying Elbert formation in the same region, no Dipterine remains were collected from the Colorado Devonian until the year 1909, when detached dental plates referable to three species already known from the Iowa Devonian were obtained by Doctor Cross. These specimens are now preserved in the Museum collection, and may be identified as belonging to *Dipterus mordax*, *D. pectinatus*, and *D. digitatus*. A single smooth crushing plate suggestive of the Synthetodus type of dentition is also contained in the collection made at the new locality, which is in the Elbert formation of Florida Valley, east side, in the Ignacio Quadrangle of southwestern Colorado.

A more particular account of these remains has recently been published (1915) in the Annals of the Carnegie Museum.[2] It may be here stated, without entering into details, that the evidence furfurnished by the three above-named species of *Dipterus*, and one undescribed *Synthetodus*-like plate, is sufficient for establishing a close correlation between the Elbert formation of Colorado and the Upper Devonian of the Cedar Valley region of Iowa. According to this correlation a somewhat later age must be assigned to the Ouray limestone than has hitherto been conceded.[3] The recent discovery of Dipterine remains in the San Juan country also simplifies the problem of distribution of this class of fishes in the Devonian. For we now find evidence that the line of communication between the Appalachian and Cordilleran regions during late Devonian times was actually by way of the Ohioan and Dakotan seas; and also that intermigration took place between the faunas of the Elbert formation and the so-called State Quarry beds of Iowa toward the close of the Devonian. This statement finds further confirmation in a discovery made by Dr. E. Kirk during the past year (1914) of a well-preserved *Dipterus* dental plate from the type section of the Jefferson limestone on Gallatin River, near Logan, Montana. The specimen has been recently added to the Museum collection. In plate 7, fig. 6, is shown a Coccostean ventro-lateral plate from the Elbert formation of the San Juan region, collected by Doctor Cross. Although clearly of arthrodiran

[1] Stauffer, C. S. The Middle Devonian of Ohio. Bull. Geol. Surv. Ohio, 1909, No. 10, p. 196.

[2] Eastman, C. R. Dipterus remains from the Upper Devonian of Colorado. Annals Carnegie Mus., vol. 9, 1915, No. 3, pp. 279–283.

[3] Hay, O. P. Description of a new species of Cladodus (*C. formosus*) form the Devonian of Colorado. Amer. Geologist, vol. 30, 1903, pp. 373–374. Girty, G. H. Devonian fossils from Colorado. The fauna of the Ouray limestone. 20th Ann. Rept. U. S. Geol. Surv., 1900, pt. 2, pp. 25–81. The Devonian fauna of the Ouray limestones. Bull. U. S. Geol. Surv., 1909, No. 391, 36 p., 10 pls.

nature, it is not capable of precise systematic determination. The text-figure 2, copied from a recent paper by Dr. W. K. Gregory, permits of a comparison of the cranial pattern of *Dipterus* and *Scaumenacia*. In still later studies by D. M. S. Watson and Henry Day (1916), slightly different homologies are recognized than those here indicated.

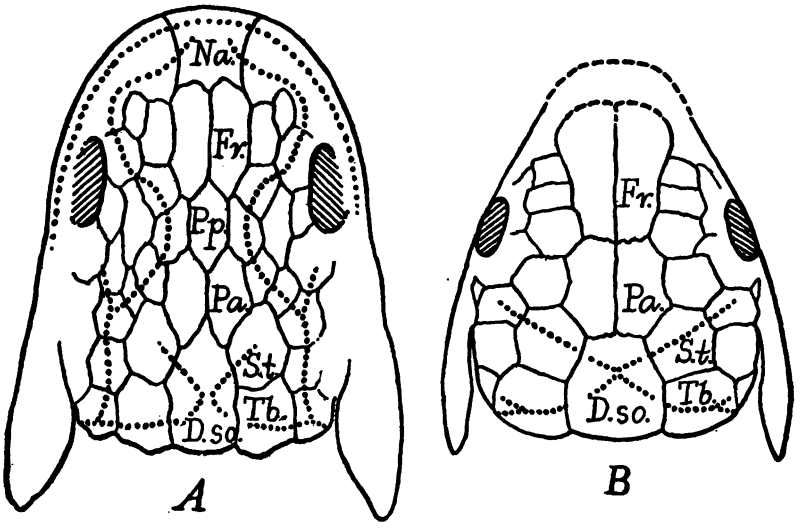


FIG. 2.—PATTERN OF SKULL-TOP OF DEVONIAN DIPNOANS. *A*, DIPTERUS VALENCIENNESI, AFTER GOODRICH, SLIGHTLY MODIFIED BY W. K. GREGORY. *B*, SCAUMENACIA CURTA, AFTER HUSSAKOF. IN SPECIMENS OF DIPTERUS THE NUMEROUS SENSORY PITS ARE SCATTERED OVER BROAD TRACTS, THE GENERAL DIRECTIONS OF WHICH ARE INDICATED BY THE DOTTED LINES, EXCEPT IN THE OCCIPITAL REGION WHERE THE DOTTED LINES REPRESENT SHALLOW GROOVES. THE "PARIETALS," "FRONTALS," ETC., ARE PROBABLY NOT HOMOGENOUS WITH THOSE OF TETRAPODA. *Dso*, DERMOSUPRAOCCIPITAL; *Fr*, FRONTALS; *Na*, NASOETHMOID REGION; *St*. SUPRATEMPORAL (PTEROTIC); *Tb*, TABULARE (EPIOTIC); *Parietal*, PREPARIETAL.

DIPTERUS ANGUSTUS (Newberry).

Plate 8, fig. 5.

Sagenodus angustus NEWBERRY, Trans. N. Y. Acad. Sci., vol. 16, 1897, p. 303, pl. 24, fig. 26.

The holotype, and until recently, the solitary known example of this species, is a worn and imperfectly preserved dental plate from the Catskill of Bradford County, Pennsylvania, now the property of the American Museum of Natural History. The illustration given of it in Newberry's posthumous paper is unsatisfactory, as it would seem to represent a complete tooth, disengaged from the matrix, and with nearly smooth superficial ridges. In point of fact the tooth is embedded in a block of hard sandstone, and the extermal margin is partially concealed by matrix, so that the entire outline of the tooth is not visible. Moreover, although the oral surface is considerably worn, it is plain that all of the ridges were tuberculated, this condition being very distinct in the two posterior ridges. As noted by Newberry, the anterior ridge is widely divergent from the others

A second specimen (pl. 8, fig. 5), preserved in the form of an impression, and apparently referable to this species, is contained in the United States National Museum collection. It is from the Chemung of Bradford County, Pennsylvania, and agrees closely in form and size with the type of *D. angustus* except that it displays one additional ridge near the posterior extremity, and all of the radiating ridges are distinctly tuberculated. The same separation is observed between the two anterior ridges as was noted by Newberry in his description of the type. The characters of this species resemble those of *Ctenodus serratus*, from the Coal Measures of Ohio, more nearly than other described species of Dipterus.

Family COCCOSTEIDAE Smith Woodward.

Genus DINICHTHYS Newberry.

Among the interesting remains of this genus contained in the United States National Museum collection may be mentioned the type mandible (Cat. No. 65) upon which the species *D. newberryi* Clarke was founded, from the Genesee shale of Bristol, New York. Another figured specimen is part of the head-shield of *D. pustulosus* Eastman (Cat. No. 19) from the Hamilton limestone of Milwaukee, Wisconsin. Indications of the same species in the Upper Devonian State Quarry beds of Johnson County, Iowa, have recently been discovered by Prof. Abram O. Thomas, of Iowa State University. Particularly noteworthy among the specimens obtained by him is a portion of the dorsomedian shield showing the posterior carinal process. It is shown in plate 8, fig. 8. The corresponding element of a closely related species from the Upper Devonian of Louisiana, Missouri, has recently been described under the name of *D. missouriensis* by E. B. Branson.[1] Some fragmentary Dinichthyid plates from the same locality are preserved in the Museum collection.

The older restorations of *Dinichthys* and allied European coccosteean genera are well known. Within recent years several writers have proposed certain modifications of the earlier arrangements of cranial and body plates in typical genera, not all of which can be said to be entirely successful. The latest attempted reconstruction of *Dinichthys terrelli* is that of E. B. Branson, published in the Ohio Naturalist for June, 1908,[2] which drew forth some critical comment by Bashford Dean in Science three years later (vol. 34, p. 801). The typical species of *Coccosteus*, and also that commonly referred to "*Brachydirus*" under von Koenen's term of *B. bidorsatus*, were made the subject of new reconstructions by G.

[1] Branson, E. B. The Devonian fishes of Missouri. Bull. Univ. Missouri, vol. 15, 1914, No. 31, p. 61, pl. 2, fig. 4.

[2] Vol. 8, pp. 363-369.

Gürich [1] in 1891, and some further changes in the restoration of Coccosteus were proposed in a series of articles by Otto Jaekel,[2] published during the first decade of the present century. Concerning one of the restorations put forward by the last-named author, that of the cranial shield of his so-called *Pachyosteus bulla*, it is to be noted that the pattern of plate arrangement is almost precisely the same as observed in primitive species of *Dinichthys*. This will be obvious from a comparison of the annexed text-figures 3 and 4, showing respectively the Wildungen species and *D. halmodeus* from the New York Devonian.

DINICHTHYS TUBERCULATUS Newberry.

Plate 2, fig. 1.

Dinichthys tuberculatus NEWBERRY, Monogr. U. S. Geol. Surv., vol. 16, 1889, p. 98, pl. 32, fig. 3.

Of this species only isolated plates of the body armor are known, most of them imperfectly preserved. Only one, an antero-dorso-

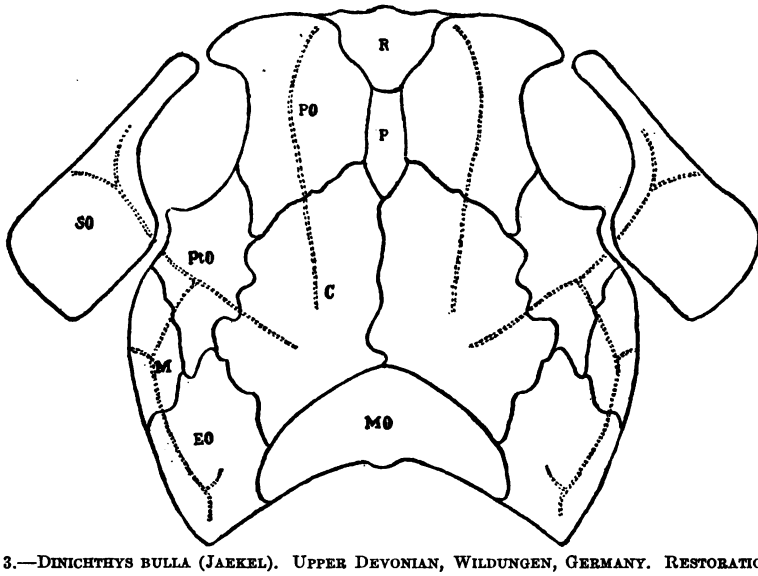


FIG. 3.—DINICHTHYS BULLA (JAEKEL). UPPER DEVONIAN, WILDUNGEN, GERMANY. RESTORATION OF HEAD-SHIELD, SLIGHTLY MODIFIED AFTER JAEKEL. *C*, CENTRAL; *EO*, EXTERNAL OCCIPITAL; *M*, MARGINAL; *MO*, MEDIAN OCCIPITAL; *P*, PINEAL; *PO*, PREORBITAL; *PtO*, POSTORBITAL; *R*, ROSTRAL; *SO*, SUBORBITAL.

lateral element, from the Chemung of Warren, Pennsylvania, was figured by Newberry. Regarding this species, this author remarks:

> In size this fish was comparatively small; the suprascapular plates are about three inches in length and breadth and nearly half an inch in thickness at the center. . . . The dorsomedian is also very small; it was not more than three inches in breadth and length, judging from the portion preserved.

[1] Gürich, G. Ueber Placodermen und andere devonische Fischreste in Breslauer mineralogischen Museum. Zeitschr. Deutsch. Geol. Ges., vol. 43, 1891, pp. 902–913.

[2] Jaekel, O. Ueber Coccosteus und die Beurtheilung der Placodermen Sitzber. Ges. Naturf. Freunde Berlin, 1902, No. 5, pp. 103–115; Ueber die Organisation und systematische Stellung der Asterolepiden. Zeitschr. Deutsch. Geol. Ges., vol. 55, 1903, Mai-Protokoll, pp. 41–60; Einige Beiträge zur Morphologie der ältesten Wirbeltiere. Sitzber. Ges. Naturf. Freunde Berlin, 1906 No. 7, pp. 180–189; 1907, p. 172, text fig. 1.

Among the arthrodiran plates in the United States National Museum collection from the same horizon and locality are several that may be provisionally referred to this species, but owing to failure of preservation of the superficial ornament, a positive determination of the species is impossible. There is a tolerably complete antero-

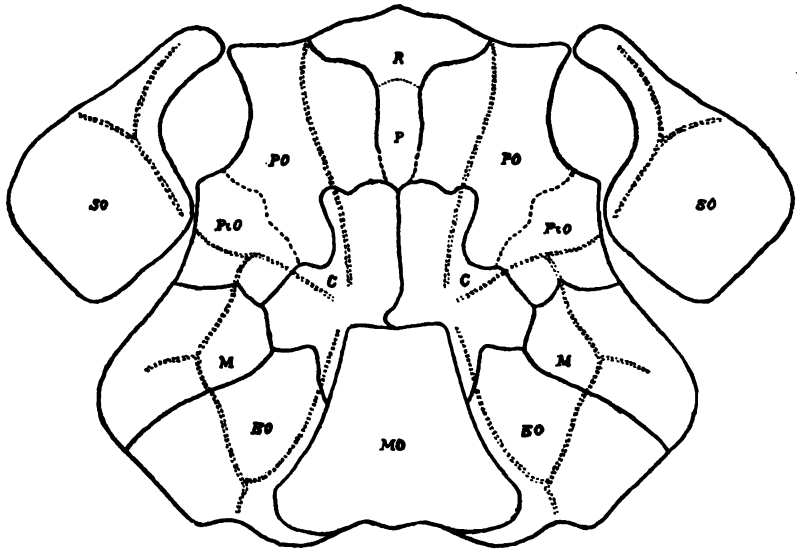


FIG. 4.—DINICHTHYS HALMODEUS (CLARKE). MARCELLUS SHALE (ERIAN), LIVONIA SALT SHAFT, NEW YORK. RESTORATION OF HEAD-SHIELD×⅔. LETTERING AS IN FIG. 3.

ventro-lateral plate in the collection, of relatively small size, and also a very good example of the dorsomedian, which has not been previously figured for this species. It is shown of slightly less than the natural size in plate 2, figure 1.

Formation and locality.—Chemung group (Upper Devonian); Warren County, Pennsylvania.

Genus MYLOSTOMA Newberry.

The arrangement of the grinding elements constituting the upper dentition of the best-known species of this genus, *M. variabile*, has been the subject of much discussion during recent years, chiefly by American writers. Up to the present time no evidence has been found of the occurrence of a pair of vomerine teeth in this genus corresponding to the so-called "premaxillary" teeth (in reality vomerine) of *Dinichthys;* but that a pair of such elements was developed is rendered at least a plausible supposition from analogy with *Dinomylostoma*, from the Portage shale of western New York.

Whereas in former years the problem of orientation of palatal grinding plates depended upon more or less theoretical considerations, we are now fortunately provided with evidence of the most positive

kind for the allocation of parts entering into the upper dental pavement. The evidence referred to is furnished by a single large compound plate, representing the fused members of the anterior pair of mylostomid dental plates, found in the isolated condition, and originally described by Louis Hussakof [1] in 1909 as the type of a distinct genus and species of Arthrodives. It has been suggested by the present writer [2] that the new genus proposed by Doctor Hussakof, and named by him *Dinognathus*, be maintained in a provisional sense,

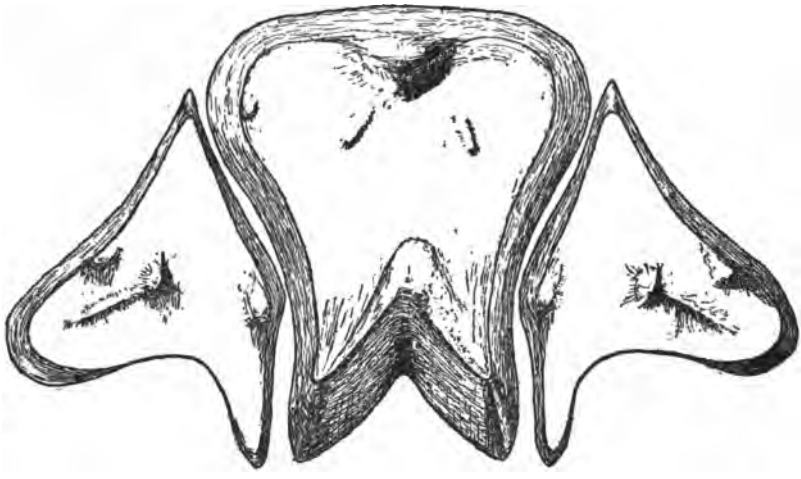


FIG. 5.—DINOGNATHUS FEROX (HUSSAKOF). CLEVELAND SHALE (UPPER DEVONIAN), LORAIN COUNTY, OHIO. RECONSTRUCTION OF THE UPPER DENTAL PAVEMENT.

and that there should be associated with it, on theoretical grounds, the unique mandible serving for the type of Newberry's species, *Mylostoma terrelli*.

A recent examination of the type material of both *Mylostoma* and *Dinognathus*, now preserved in the American Museum of Natural History, has satisfied the writer of the entire correctness of this view; and in text-figure 5 is illustrated our conception of the arrangement of the palatal dental elements of *Dinognathus*. It is to be noted that in this genus the anterior pair of palato-pterygoid dental plates is fused into a single crushing element. In *Dinichthys*, on the other hand, the so-called "shear-tooth" is to be interpreted as having arisen from the fusion of the anteriorly and posteriorly placed elements on either side of the upper jaw.

[1] Hussakof, L. The systematic relationships of certain American Arthrodires. Bull. Amer. Mus. Nat. Hist., vol. 26, 1909, p. 268, fig. 5.

[2] Science, vol. 29, 1909, p. 997; Bull. Mus. Comp. Zool., 1909, vol. 52, pp. 261-269.

TELEOSTOMI.

Family RHIZODONTIDAE Traquair.

Genus SAURIPTERUS Hall.

SAURIPTERUS TAYLORI Hall.

Plate 2, fig. 2; plate 7, fig. 5.

Sauripteris taylori HALL, Nat. Hist. N. Y., pt. 4, Geology, 1843, p. 282, text-fig. 130.—NEWBERRY, Monogr. U. S. Geol. Surv., vol. 16, 1889, p. 112.—BROOM, Bull. Amer. Mus. Nat. Hist., vol. 32, 1913, pp. 459–463; Anat. Anz., vol. 45, 1913, pp. 73–78.—GREGORY, Ann. N. Y. Acad. Sci., vol. 26, 1915, pp. 358–362.

The extent of our information in regard to this genus has recently been summed up by Dr. Robert Broom, as follows:[1]

Sauripterus is known only by fragments of the head, a series of crushed vertebræ, a large number of scales and the beautifully preserved right pectoral fin with most of

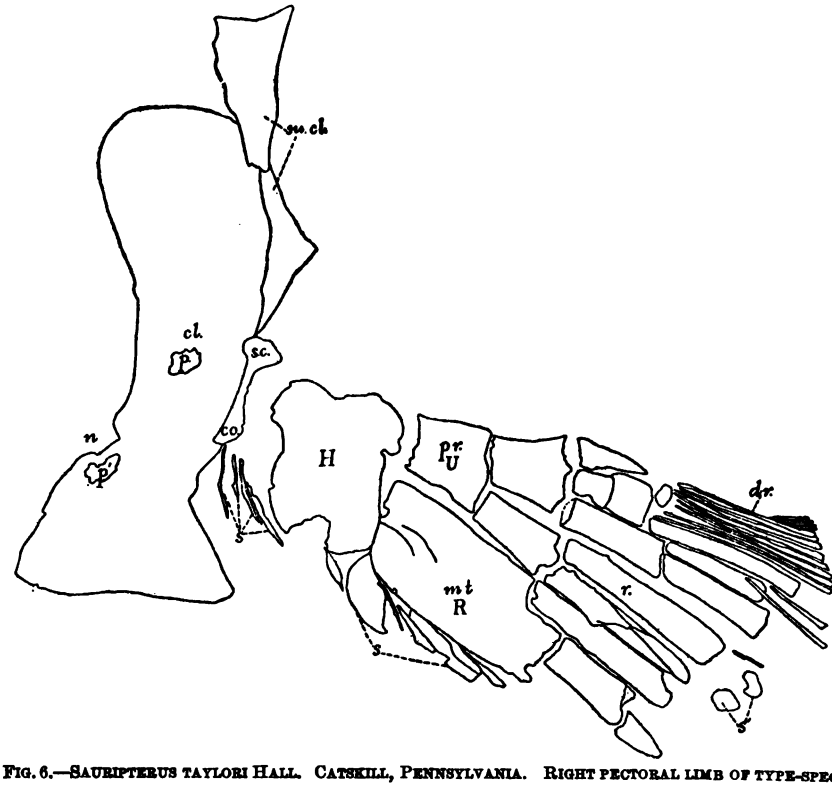


FIG. 6.—SAURIPTERUS TAYLORI HALL. CATSKILL, PENNSYLVANIA. RIGHT PECTORAL LIMB OF TYPE-SPECIMEN WITH PARTS IN THEIR NATURALLY ASSOCIATED POSITION. (AFTER W. K. GREGORY).

the cleithrum and part of the supraclavicle (text fig. 6). The large comparatively thin scales resemble those of *Rhizodopsis* and the cleithrum closely resembles that of *Rhizodus*. The vertebral centra are formed by rings of bone. Owing to the crushed condition of the vertebrae it is impossible to be quite sure whether the ring is entire or

[1] Bull. Amer. Mus. Nat. Hist., vol. 32, 1913, p. 461. See, also, on the Rhipidistia, the important article by D. M. S. Watson and Henry Day in Mem. and Proc. Manchester Lit. and Philos. Soc., vol. 60, 1916, pt. 1, pp. 1–52.

made up of four parts. There is certainly a well-ossified neural arch and above this in some of the vertebrae at least a well-developed flattened neural spine. The teeth have the enamel deeply folded at the bases as seen in the figures given.

This passage is followed by a detailed description of the pectoral limb in the type-specimen, now preserved in the American Museum of Natural History; but there is no further discussion of the head parts. Still more recently the limb structure of the Rhipidistia, as exemplified by the same type-specimen of *Sauripterus* has been made the subject of searching investigation and comparison with other

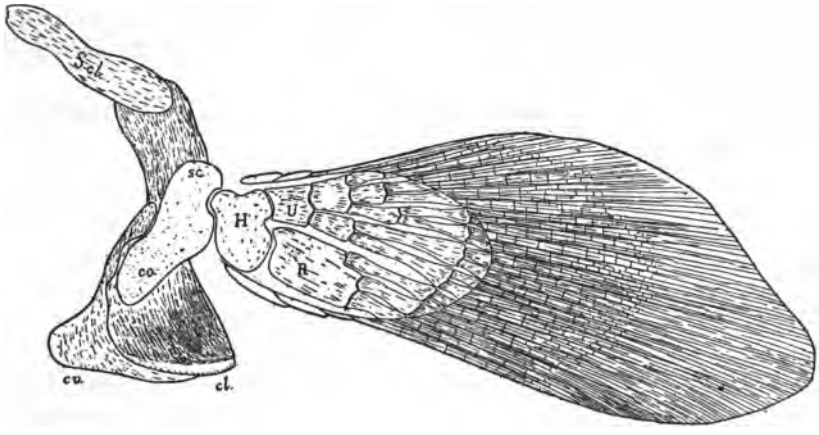


FIG. 7.—SAURIPTERUS TAYLORI HALL. CATSKILL, PENNSYLVANIA. RESTORATION OF THE RIGHT PECTORAL LIMB, SEEN FROM THE INNER SIDE. THE MESOPTERYGIAL SERIES IS REPRESENTED BY THE HUMERUS (H), ULNA (U) AND DISTALLY SUCCEEDING ELEMENTS; THE PREAXIAL RADIALS (R) ARE BARELY REPRESENTED. THE SCAPULACORACOID, CLAVICLE (*cv*), SUPRACLEITHRUM (*s. cl.*), AND FIN RAYS ARE CONJECTURALLY RESTORED FROM ANALOGY WITH RELATED GENERA. (AFTER W. K. GREGORY).

ichthyic and tetrapod appendages in a paper published during the present year by Dr. W. K. Gregory.[1]

As a result of his investigations Dr. Gregory adopts the view, already advocated by Doctor Broom, that the ascending blade in the shoulder-girdle of *Sauripterus* (text fig. 6) represents the cleithrum of primitive Stegocephali; and accordingly, he is able to recognize the the following homologies of parts:

RHIPIDISTIA.	PRIMITIVE TETRAPODA.
Interclavicular corium.	Interclavicle.
Clavicle ("infraclavicle").	Clavicle.
Supracleithrum ("supraclavicle").	?Fused with top of cleithrum.
Post-temporal.	Lost.
Coracoscapula.	Coracoscapula.
Fleshy lobe of fin.	Arm and hand.
Mesopterygium (single basal piece).	Humerus.
Mesopterygial axis.	Humerus, ulna, ulnare, digit V (?)
Preaxial parameres (radials) reduced or absent.	Lost.
Postaxial parameres.	Radius, carpus, digits I–IV (?)
Dermal rays.	Lost.

[1] Ann. N. Y. Acad. Sci., vol. 26, 1915, pp. 358–362.

The only specimen showing a portion of the cranial roof that has thus far come to light is that illustrated in plate 2, fig. 2, which shows the parietals, frontals and one each of the squamosals and postfrontals in natural juxtaposition. The parietals are of about the same relative length as in *Holoptychius*, and less elongate than in *Rhizodopsis* and *Onychodus;* but further than this it is not possible to make comparisons, owing to the inadequate preservation of parts. Nevertheless, being unique, the specimen is of importance for the bare hint it affords of the arrangement of cranial roofing plates in this genus. Another fragmentary head structure, to be interpreted probably as a portion of the basisphenoid of this or some closely related form, is shown in plate 7, fig. 5.

Formation and locality.—Catskill (Upper Devonian) near Blossburg, Pennsylvania.

D. CARBONIFEROUS SYSTEM.

ELASMOBRANCHII

Family CLADODONTIDAE.

Genus CLADODUS Agassiz.

Among the specimens of fossil fishes acquired by the United States National Museum from Dr. G. Hambach, of St. Louis, is a series of well preserved teeth of Cladodont, Petalodont, and Cochliodont sharks from different horizons of the Mississippian section, and also a number of interesting ichthyodorulites, some of which add to our knowledge of established species. These are noticed in the following paragraphs under their appropriate headings.

CLADODUS SPINOSUS Newberry and Worthen.

Plate 8, fig. 7.

Cladodus spinosus NEWBERRY and WORTHEN, Pal. Illinois, vol. 2, 1866, p. 22, pl. 1, fig. 3.—E. B. BRANSON, 30th Ann. Rept, Dept. Geol. Nat. Resources Indiana, 1906, p. 1377, pl. 41, figs. 1, 2.

The large, highly ornate teeth belonging to this species are of rare occurrence in the St. Louis limestone, and few perfect specimens have been obtained. One which shows the characters of the base and lateral denticles very clearly is catalogued under the number 8104, from the Hambach collection. It is the largest of any that have come under the writer's observation, but unfortunately lacks the apical portion of the crown. From the amended definition of this species given by E. B. Branson I quote as follows:

Teeth of medium or large size, broader than high; base representing a little more than half of an imperfect hexagon, with the posterior side slightly longer than the others; thick, with a sharpish edge behind, before strong beveled, and under scooped out in a shallow sinus beneath the median cone; whole anterior border of base, above

the smooth beveled edge, set with many minute spines directed upward; these spines cover the antero-lateral edges of the base of the principal cone. Median cone conical, somewhat curved backward, rapidly tapering to an acute point; lower portion with a nearly circular section, finely and evenly striated longitudinally, near the point smooth, compressed, with cutting edges; lateral denticles 6-7 on either side, conical, striated and curved backward, exterior pair much larger than intermediate ones.

Formation and locality.—St. Louis limestone, Missouri.

CLADODUS ACULEATUS, new species.

Plate 10, fig. 4; plate 18, fig. 1.

Teeth small, the crown consisting of a long, slender, erect, and pointed median cone, with faint longitudinal striae, and a pair of similar lateral cones rising to about half the height of the principal cone, only slightly divergent, and all three with slight sigmoidal curvature. Root short, not very deep.

The teeth in this species are of relatively small size and gracefully formed. They agree more nearly in general form with *C. gracilis* Newberry and Worthen, from the Coal Measures of Indiana, but are distinguished from this and from other known species by the greater height of the lateral denticles and their closer approximation to the principal median cone, which is extremely slender from base to apex. In the specimen selected as type (Cat. No. 8106, U.S.N.M.) of the new species, the total height is only about 11 mm., and a second specimen in the same collection is still smaller.

The two known specimens which have been obtained of this species are each contained in small black concretions found in the Caney shale of Antlers Quadrangle, Oklahoma, the exact locality being that referred to as No. 3987 in Doctor Girty's paper on the Fauna of the Caney Shale of Oklahoma.[1] An extensive collection of fossiliferous nodules from this and other localities in the same region was made by Doctor Girty, and is now preserved in the United States National Museum. Comparatively few of these concretions contain fish remains, but among them are several interesting forms, such as spines of *Stethacanthus*, arthrodiran body plates, and small Palaeoniscids showing the internal structure of the head. Two Coccosteus-like antero-ventro-lateral plates are shown in plate 10, figures 5 and 6. These remains are noticed hereinafter.

The only mention that has previously been made of the occurrence of fish remains in the Caney shale is to be found in Doctor Girty's discussion of the fauna in Bulletin 377 of the Geological Survey. The author there remarks (p. 13):

Another neglected type is the fishes, represented not only by teeth but by what appear to be fragments of bone. In this connection may be mentioned agglomerations of organic fragments, possible of coprolitic origin, which occur as a rule in small concretions.

[1] Bull. U. S. Geol. Surv., No. 377, 1909, p. 75.

About 50 species of invertebrates are known from the Caney shale, and the beds are tentatively correlated in age with the uppermost Mississippian or base of the Pennsylvanian.

CLADODUS COMPRESSUS Branson.

For purposes of bibliographical record it may be stated here that the type-specimen upon which this species is founded was named *Cladodus striatus* in the original description.[1] It was pointed out by the present writer[2] that this name could not be used, Agassiz having already applied it to the type species of *Cladodus*; and in an article published in Science,[3] Doctor Branson proposed that it be replaced by the title of *C. compressus*.

Genus DICRENODUS Romanovsky.

Syn. *Carcharopsis* Agassiz; *Pristicladodus* M'Coy.

This genus is represented by a single species in the Mississippian rocks of this country, described by Newberry under the name of *Carcharopsis wortheni*.[4] A second North American species appears to be indicated by the specimen immediately to be described.

DICRENODUS TEXANUS, new species.

Plate 7, fig. 4.

Founded upon a unique tooth having a total height of 2.5 cm., and width at base of crown of 2 cm. In general form resembling the type of *D. wortheni* (Newberry), but anterior coronal face slightly concave, no lateral cusps at the base, and root with deep median sinus. Coronal margins strongly and evenly crenulated from the apex to the base, and summits of the lateral crenulations secondarily notched.

The type and solitary known specimen of the new cladodont just described is catalogued as No. 8097. It was collected by Prof. J. A. Udden, of the University of Texas, in 1914, from strata of Pennsylvanian age near San Saba, Texas, and by him presented to the Museum through the present writer. From the same horizon and locality Professor Udden also obtained the ichthyodroulite hereinafter referred to under the caption of *Physonemus gemmatus*.

Family PETALODONTIDAE Newberry and Worthen.

Of this extinct family only a single genus is known, *Janassa*, in which other skeletal parts have been found in natural association with the dentition. No fin-spines are known to occur in this genus, hence it is unlikely that such defenses were present in other members of the same family. Jaekel, however, in a valuable article on the

[1] 30th Ann. Rept. Dept. Geol. Nat. Resources Indiana, 1906, p. 1378.
[2] Memoir 10, N. Y. State Museum, 1907, p. 62.
[3] Vol. 27, 1908, p. 311.
[4] Pal. Illinois, vol. 2, 1866, p. 69, pl. 4, fig. 14.

structure of Petalodonts,[1] has suggested that the fin-spines known as *Stichacanthus* and *Physonemus* (including *Xystracanthus* and *Batacanthus*) should be associated on theoretical grounds with the teeth of *Polyrhizodus* and *Petalodus* respectively. He also conjectured that the teeth of *Petalodus* and *Ctenoptychius* were borne in the mouth of one and the same genus of Palaeozoic sharks.

Genus POLYRHIZODUS M'Coy.

Syn. *Dactylodus* Newberry and Worthen.

As remarked by Dr. A. S. Woodward in his Catalogue of Fossil Fishes in the British Museum (Part 1, p. 56), "no teeth of this genus having been found thus far in natural association, it is impossible to distinguish between specific characters and the variations exhibited by teeth in different parts of a single jaw." There is, however, some reason in support of Jaekel's surmise that the teeth of *Polyrhizodus* are associated in the same jaw with those having low and elongate crowns, commonly referred to *Chomatodus*.

POLYRHIZODUS CONCAVUS (St. John and Worthen).

Plate 8, fig. 4.

The teeth of this species resemble those of *P. princeps* (the type species of the so-called "*Dactylodus*"), but are smaller, and the base of the crown is more strongly arched downward in the middle. A single specimen in the Museum collection, catalogued as No. 8100, is peculiar in showing an apparently undivided root.

Formation and locality.—St. Louis limestone (Mississippian); near Alton, Illinois (from the Hambach collection).

POLYRHIZODUS GRANDIS, new species.

Plate 8, figs. 1, 2.

Teeth robust and of relatively large size, laterally elongated, with moderately high crown, the base line not much curved on the posterior face; the root subdivided into six or more tumid branches.

This species is founded upon two specimens in the United States National Museum collection, catalogued as Nos. 8104 and 8116, one of which has the crown very excellently preserved, but lacks a part of the root, and the other shows the latter structure in nearly perfect condition, but has the crown somewhat worn and fractured.

Probably to this species should be referred certain low and elongate *Chomatodus*-like teeth occurring in the same formation, by analogy with the association of two very similar types of teeth belonging to *P. concavus* Trautschold, from the Russian Coal Measures. This is in

[1] Jaekel, Otto, Ueber die Organisation der Petalodonten. Zeitschr. Deutsch. Geol. Ges., vol. 51, 1899, pp. 258-298.

accordance with Jaekel's proposed association of parts, already referred to.[1] One such tooth in the National Museum collection is catalogued as No. 8103, and represented of the natural size on plate 8, figure 6.

Formation and locality.—St. Louis limestone (Mississippian); near Alton, Illinois (from the Hambach collection).

Family PSAMMODONTIDAE De Koninck.

Genus PSAMMODUS Agassiz.

The teeth in this genus are quadrate, more or less elongated, rarely nearly square; root much thicker than the crown, and readily detached from the latter; coronal surface generally marked by transverse rugae, complete dentition consisting of from two to four longitudinal rows of pavement teeth in different species, as inferred from their form and marks of mutual contact.

PSAMMODUS PLENUS St. John and Worthen.

Plate 7, fig. 8.

Psammodus plenus ST. JOHN and WORTHEN, Pal. Illinois, vol. 7, 1883, p. 213, pl. 16, figs. 1–4; pl. 17, figs. 1–4.

Psammodus glyptus NEWBERRY (*errore*), Monogr. U. S. Geol. Surv., vol. 16, 1889, p. 210, pl. 19, figs. 7, 8.

The teeth of this species attain large size, and, according to the original authors, it is possible to distinguish between those belonging to upper and lower dental pavements. The form supposed by them to pertain to the upper jaw is described as "subrhomboidal, or of a laterally elongate-trapezoidal outline, gently arched antero-posteriorly." The supposed mandibular teeth "are distinguished by their subquadrangular outline and relatively narrower transverse diameter compared to the length."

According to the interpretation of the authors just quoted the teeth "were ranged in double rows upon the jaws," in the same manner as indicated by them in the case of *P. springeri*, and by Newberry in the case of his so-called *Archaeobatis gigas*, which latter can scarcely be maintained as a distinct genus. There exist, however, certain teeth of *P. plenus* which from their bilateral symmetry are assignable to a median position in the mouth, either above or below; and these were evidently bordered on either side by a row of lateral teeth. Two such teeth which we interpret as indicative of a median unpaired row have already been figured by Newberry under the erroneous designation of *P. glyptus*;[2] the original specimens are now preserved in the American Museum of Natural History, and have been compared by the writer with other teeth of the same species. The markings

[1] Zeitschr. Deutsch. Geol. Ges., vol. 51, 1899, p. 280.

[2] Monogr. U. S. Geol. Surv., vol. 16, 1889, pl. 19, figs. 7, 8.

in allusion to which the specific title was bestowed are the result partly of wear and partly of discoloration along concentric lines of growth, as shown by the arrangement of the pores in which the fine tubules terminate.

A number of well preserved examples of this species, all from the St. Louis limestone, are contained in the National Museum collection. An unusually large-sized grinding tooth, collected by G. Hambach, is shown of slightly less than the natural size in plate 7, fig. 8.

Formation and locality.—St. Louis limestone; near St. Louis, Missouri; also Illinois and Michigan.

Family COCHLIODONTIDAE Owen.

Genus PSEPHODUS Agassiz.

As in *Cochliodus*, so also in *Psephodus* and closely allied genera, it is probable that a series of helodoid teeth was associated in the same mouth as the large posteriorly placed grinding plates, which latter have resulted from the fusion of a double series on either side of the jaw above and below of narrow and elongate elements. A review of the literature describing the association of *Psephodus* and *Helodus*-like teeth has been given by E. B. Branson;[1] and the conclusion reached by this author is that probably in *Cochliodus* as well as in *Psephodus* no helodoid teeth were present in the complete dentition. Branson's view, which is directly contrary to the prevailing opinion of palaeichthyologists, is based upon his interpretation of the type of the following-named species.

PSEPHODUS LEGRANDENSIS Branson.

Plate 18, fig. 2.

Psephodus legrandensis BRANSON, Journ. Geol., vol. 13, 1905, p. 24, pl. 1, fig. 2.

The unique specimen serving as the type of this species shows the two series of crushing plates belonging to both halves of the same jaw, and it is supposed by the original author that these elements lie in their undisturbed natural position. It is further supposed by him that they were preceded in front by a pair of small-sized triangular teeth which were in contact with each other along the median line. According to this conjectural reconstruction, as stated by the author,[2] "no place remains on the jaw for the helodoid teeth which have been so generally considered as forming a component part of the dentition of this genus.

Through the kindness of Dr. Stuart Weller, of the University of Chicago, the present writer has had the privilege of examing the type

[1] Branson, E. B., Notes on some Carboniferous Cochliodonts, with descriptions of seven new species. Journ. Geol., vol. 13, 1905, pp. 20–34.

[2] Idem, p. 20.

specimen, which is now the property of the Walker Museum (Cat. No. 10038).

To the mind of the present writer the conclusion is irresistible that the anterior and posterior plates present in the right and left hand sides of the jaw have been crowded against one another so as to lie in juxtaposition along the median line as the result of post-mortem deformation. They did not naturally form a compact pavement during life, but the right and left halves were separated, leaving a V-shaped area between them, as in *Cochliodus*. This inferred separation throughout their length would permit of the presence of a series of *Helodus*-like teeth in contact with the front margin of the anterior pair of grinding plates, and it is not necessary to assume that their place was taken by a single pair of small triangular teeth. In a word, the evidence furnished by the type of this species does not appear to be irreconcilable with well established reconstructions of Psephodont and Cochliodont dentition.

Genus DELTODUS Agassiz.

A discussion of the relations between this genus and *Sandalodus* was published by E. B. Branson a decade ago, in an article entitled Notes on Carboniferous Cochliodonts.[1] We are not able to share this author's view that only a single dental plate is present on each side of the jaw above and below in *Sandalodus* instead of three, as in *Deltodus* and most Cochliodonts. Again, in his discussion of the teeth commonly known as *Deltodus occidentalis*, he undertakes to remove this species to *Sandalodus*, "because there is evidently only one tooth to each ramus of the jaw." This latter statement is merely an assumption resting upon negative evidence, and no proof has yet been adduced to show that the number of dental elements present in the mouth of *Sandalodus* was the same as in *Deltodus*.

DELTODUS OCCIDENTALIS (Leidy).

Plate 8, fig. 3.

Cochliodus occidentalis LEIDY, Trans. Amer. Philos. Soc., vol. 11, 1857, p. 88, pl. 5, figs. 3–16.

Deltodus occidentalis EASTMAN, Bull. Mus. Comp. Zool., vol. 39, 1902, p. 200, pl. 4, fig. 38; pl. 5, fig. 53.

Sandalodus occidentalis BRANSON, Journ. Geol., vol. 13, 1905, p. 27, pl. 1, figs. 8, 9.

Sandalodus occidentalis BRANSON, 30th Ann. Rept. Dept. Geol. Nat. Resources Indiana, 1906, p. 1384, pl. 41, fig. 33.

The complete synonymy of this species is given in the above-cited articles by E. B. Branson and the present writer. In our opinion, however, Dootor Branson is in error in transferring the species to the

[1] Journ. Geol., vol. 13, 1905, pp. 25–27.

genus *Sandalodus*, solely on account of our lack of knowledge of the anterior components of the complete dentition. The form of the large crushing teeth of this species is unmistakably that of *Deltodus*, as may be seen from an inspection of the example shown on plate 8, fig. 3, which is from the St. Louis limestone near St. Louis, Missouri. In geological range the species extends from the Burlington to the St. Louis limestone, inclusive.

ICHTHYODORULITES.

Under this head mention is made of certain interesting dermal defenses of Carboniferous sharks which are preserved in the collection and are worthy of special notice. The interpretation of some of these structures as belonging to primitive Chimaeroids is a novel feature. Generic names founded upon fin-spines and clasping organs are to be understood as used in a provisional sense only.

Genus CTENACANTHUS Agassiz.

In the year 1902 descriptions were published by the present writer[1] of several Kinderhook species of this genus, the types of which had been acquired by the United States National Museum. At the time of their description an exact record of the locality was unobtainable, but at a later date the information was received from Prof. Charles Schuchert that the types of *C. longinodosus*, *C. lucasi*, *C. decussatus*, and *C. solidus*, together with the figured specimens of *C. spectabilis* and *C. venustus*, were collected from the Kinderhook quarries at Le Grand, in Marshall County, Iowa. The formation as exposed in this vicinity is described in the Annual Report of the Iowa Geological Survey, vol. 7, 1896, pp. 221–226.

CTENACANTHUS GRACILLIMUS Newberry and Worthen.

Plate 5, fig. 4; plate 7, fig. 7.

Ctenacanthus gracillimus NEWBERRY and WORTHEN, Pal. Illinois, vol. 2, 1866, p. 126, pl. 13, fig. 3.—ST. JOHN and WORTHEN, Pal. Illinois, vol. 7, 1883, p. 238, pl. 24, fig. 1.

Acondylacanthus occidentalis NEWBERRY, Monogr. U. S. Geol. Surv., vol. 16, 1889, p. 206, pl. 25, fig. 6.

The reasons for uniting the "species" described by Newberry and Worthen as *Peltacanthus* (?) *occidentalis* with *C. gracillimus* of the same authors were pointed out by St. John and Worthen in 1883, and reaffirmed by the present writer in 1902.[2] Under the designation of *Acondylacanthus occidentalis* a distorted and worn spine from the St. Louis limestone was figured by J. S. Newberry in 1889, evidently through erroneous interpretation. The specimen should properly be referred to the species now under discussion, and a more per-

[1] Bull. Mus. Comp. Zool., vol. 39, No. 3.
[2] Idem., p. 86.

feet example, from the same horizon and locality, is shown in our plate 7, figure 7. In this, however, as in most examples of this species and of *Physonemus* from the St. Louis limestone, the fine details of tuberculate ornamentation have become obliterated. A smaller and more arcuate spine, or rather, the distal portion of one, presumably of the same species, is shown in plate 5, figure 4. Its curvature and smooth costae are suggestive of *Acondylacanthus attenuatus* Davis, from the Lower Carboniferous limestone of Ireland, but it has a narrower transverse section, and is best regarded as a rather strongly arched example of *C. gracillimus*. It is catalogued as No. 8101.

LIST OF SPECIES OF CTENACANTHUS OCCURRING IN THE MISSISSIPPIAN SERIES.

1. *C. coxianus* St. John and Worthen ..... Kinderhook; also Keokuk.
2. *C. decussatus* Eastman ..... Kinderhook; also Keokuk.
3. *C. depressus* Newberry ..... Kinderhook limestone.
4. *C. longinodsus* Eastman ..... Kinderhook limestone.
5. *C. lucasi* Eastman ..... Kinderhook limestone.
6. *C. sculptus* St. John and Worthen ..... Kinderhook limestone.
7. *C. semicostatus* St. John and Worthen ..... Kinderhook limestone.
8. *C. solidus* Eastman ..... Kinderhook limestone.
9. *C. spectabilis* St. John and Worthen ..... Kinderhook limestone.
10. *C. varians* St. John and Worthen ..... Kinderhook limestone.
11. *C. venustus* Eastman ..... Kinderhook limestone.
12. *C.*(?) *burlingtonensis* St. John and Worthen ..... Burlington limestone.
13. *C. gradocostatus* St. John and Worthen ..... Burlington limestone.
14. *C. acutus* Eastman ..... Keokuk limestone.
15. *C. cylindricus* Newberry ..... Keokuk limestone.
16. *C. excavatus* St. John and Worthen ..... Keokuk limestone.
17. *C. keokuk* St. John and Worthen ..... Keokuk limestone.
18. *C. xiphias* St. John and Worthen ..... Keokuk limestone.
19. *C. costatus* Newberry and Worthen ..... St. Louis limestone.
20. *C. deflexus* St. John and Worthen ..... St. Louis limestone.
21. *C. gemmatus* St. John and Worthen ..... St. Louis limestone.
22. *C. gurleyi* Newberry ..... St. Louis limestone.
23. *C. harrisoni* St. John and Worthen ..... St. Louis limestone.
24. *C. littoni* Newberry ..... St. Louis limestone.
25. *C. pellensis* St. John and Worthen ..... St. Louis limestone.
26. *C. angulatus* Newberry and Worthen ..... Chester limestone.
27. *C. canaliratus* St. John and Worthen ..... Chester limestone.
28. *C. similis* St. John and Worthen ..... Chester limestone.

Genus PHYSONEMUS M'Coy.

Syn. *Xystracanthus* Leidy; *Drepanacanthus* Newberry and Worthen.

The earliest and most primitive remains assignable to this "genus" are found in the Kinderhook limestone of the Mississippi Valley, where they are accompanied by small spines of *Stethacanthus*. The Burlington species of both genera are considerably larger than those from the Kinderhook, but they are feebly ornamented, and so too are the

Keokuk species. *Stethacanthus* seems to have attained its maximum size in the stage represented by the Keokuk limestone, as *Physonemus* did in the Burlington; and a marked diminution of size is observable in both genera toward the close of the Mississippian series.

A certain group of large *Physonemus*-like spines is peculiar in that the exserted portion is forwardly curved, instead of backwardly, as in most ichthyodorulites, and this feature appeared so anomalous to early authors, like Leidy, Newberry, and Worthen, as in their judgment to warrant a generic separation from *Physonemus*. Hence several species belonging to this category were described under the names of *Xystracanthus* and *Drepanacanthus*. The group of large, forwardly curved spines referred to includes such forms as the so-called *Drepanacanthus gemmatus* Newberry and Worthen, *D. anceps* Newberry and Worthen, *Xystracanthus acinaciformis* St. John and Worthen, *Physonemus gigas* Newberry and Worthen, and the defenses theoretically associated with the teeth of *Polyrhizodus rossicus* by A. Inostranzev[1] and O. Jaekel.[2] However, it seems preferable to retain all of the "species" represented by these spines within the limits of *Physonemus*, and their forward curvature favors the interpretation of these bodies as head spines and clasping organs such as are developed among recent and fossil Chimaeroids.

Following is a list of the known North American species of *Physonemus*, understood in its broader sense:

1. *P. hamus-piscatorius* Eastman.....Kinderhook.
2. *P. pandatus* Eastman.....Kinderhook.
3. *P. gigas* Newberry and Worthen.....Burlington.
4. *P. gemmatus* (Newberry and Worthen).....Keokuk.
5. *P. stellatus* (Newberry and Worthen).....Keokuk.
6. *P.* (?) *baculiformis* (St. John and Worthen).....Keokuk.
7. *P.* (?) *necis* (St. John and Worthen).....Keokuk.
8. *P. arcuatus* M'Coy.....St. Louis.
9. *P. acinaciformis* (St. John and Worthen).....Coal Measures.
10. *P. anceps* (Newberry and Worthen).....Coal Measures.
11. *P. asper* Eastman.....Coal Measures.
12. *P. mirabilis* (St. John and Worthen).....Coal Measures.

PHYSONEMUS GEMMATUS (Newberry and Worthen).

Plates 3 and 4; plate 5, fig. 3.

Drepanacanthus gemmatus NEWBERRY and WORTHEN, Pal. Illinois, vol. 2, 1866, p. 123, pl. 12, figs. 1, 2.

The only published figures of this species are imperfectly preserved spines in which the apical portion is lacking, and the inserted basal part is not completely shown. Two very large (25 cm. high) and well preserved spines belonging to the United States National Museum collection fortunately supplement each other as regards cer-

[1] Travaux Soc. Nat. St. Pétersb., vol. 19, 1888, pp. 1–18, figs. 7–10.
[2] Zeitschr. Deutsch. Geol. Ges., vol. 51, 1899, p. 281, fig. 5.

tain details; together they acquaint us with the entire outline, including the part inserted in the integument, and also show the characters of the superficial ornamentation more clearly than in the original illustrations of this species.

At first sight it may seem peculiar that the large, obliquely directed denticles seen along the concave margin near the distal extremity should occur on the anterior, instead of posterior, face of the spine. Similar conditions, however, have been noted by St. John and Worthen in the form described by them as *Xystracanthus* [=*Physonemus*] *mirabilis*, and the like is to be observed also in the still more arcuate and forwardly curved spines from the Russian Coal Measures which have been theoretically associated by Inostranzev[1] and Jaekel[2] with the teeth of *Polyrhizodus rossicus*. We should not hesitate to refer these Russian spines to the genus *Physonemus*, and the interpretation that we should place upon them is to regard them as frontal clasping organs, of the same nature as those in *Squaloraja*, *Myriacanthus*, and recent Chimaeroids.

A single arcuate spine, much weathered and preserved partly in the form of an impression, but apparently referable to this species, was obtained by J. A. Udden in 1914 from Pennsylvanian strata near San Sabo, Texas, at the same locality that yielded the type of *Dicrenodus texanus*. It is contained in the Museum collection (Cat. No. 8108) and is shown in plate 5, figure 3.

PHYSONEMUS ARCUATUS M'Coy.

Plate 5, figs. 1, 2.

Physonemus arcuatus M'Coy, Ann. Mag. Nat. Hist., [2] vol. 2, 1848, p. 117, and Brit. Palaeoz. Foss., 1855, p. 638, pl. 3 I, fig. 20.—Eastman, Bull. Mus. Comp. Zool., vol. 39, 1903, p. 208, text-fig. 12.

Spines of this species are of extremely rare occurrence in the Lower Carboniferous of the Mississippi Valley, and few perfect examples have been obtained from either this country or Great Britain. In general the known specimens are denuded of their superficial ornamentation, and the denticles along the concave margin are either worn or broken away. Two specimens which show the tuberculate ornamentation more perfectly than in any previously described example of this species are preserved in the Museum collection, and illustrated in plate 5, figures 1 and 2. They differ somewhat in general outline, one being slender and erect, and having the posterior denticles more strongly developed than in the other, which is more compact and arcuate. Nevertheless, we are not inclined to regard these differences as sufficient to warrant the establishment of a new

[1] Travaux Soc. Nat. St. Pétersb., vol. 19, 1888, pp. 1–18, with plate.

[2] Zeitschr. Deutsch. Geol. Ges., vol. 51, 1899, p. 281, text-fig. 5. The ornamentation of these spines is suggestive of certain species of *Oracanthus*.

species for the more slender variety, especially in view of the fact that the lower portion of the convex margin is not entire, and some of the posterior denticles have become lost.

Important to note is the fact that the original of plate 5, figure 2, displays very clearly the line of insertion at the base, and the direction of this line would seem to indicate that in this as in other species of *Physonemus*, the distal portion of the spine was forwardly curved. This disposes of the view formerly entertained that the *P. arcuatus* type of head-spine was homologous with the laterally compressed posterior branch of *Erismacanthus* (see pl. 7, figs. 2, 3). That this recurved portion of *Erismacanthus* spines was actually posterior in position follows as a necessary consequence of the interpretation of these organs as frontal claspers. It is probable that in *Physonemus*, as in *Heteracanthus*, the forwardly arched spines were situated immediately behind the head, at the junction with the neck.

Formation and locality.—St. Louis limestone; near St. Louis, Missouri (from the G. Hambach collection).

Genus ERISMACANTHUS M'Coy.

Of this genus two European and two American species have been described, all of the forms agreeing closely with the *Physonemus* type of frontal spine, but differing from it in that the spines are divaricated; that is, they consist of two branches extending in opposite directions in the same vertical plane. The imperfect ichthyodorulites known as *Gampsacanthus*, *Lecracanthus*, and *Dipriacanthus* appear to be of the same general nature, and may be provisionally regarded as the dissociated anterior branches belonging to *Erismacanthus*. The spines of this genus are somewhat asymmetrical, and were probably located on either side of the head region, whereas the bilaterally symmetrical *Physonemus* type of frontal spine occupied an occipital position.

ERISMACANTHUS FORMOSUS Eastman.

Erismacanthus formosus EASTMAN, Amer. Naturalist, vol. 36, 1902, p. 850, text-fig. 1; Bull. Mus. Comp. Zool., vol. 31, 1902, p. 212, text-fig. 13.

The type of this, the largest known species of the genus, was collected by Dr. G. Hambach in the St. Louis limestone of Missouri, and is now preserved in the collection of the United States National Museum.

ERISMACANTHUS MACCOYANUS St. John and Worthen.

Plate 7, figs. 2, 3.

Erismacanthus maccoyanus ST. JOHN and WORTHEN, Pal. Illinois, vol. 6, 1875, p. 461, pl. 22, figs. 1, 2, 4 (*not* fig. 3).—EASTMAN, Bull. Mus. Comp. Zool., vol. 31, 1902, p. 211.

The paired frontal claspers described under this name are all of small size, none so far as known exceeding 5 cm. in length. One of

the specimens described by the original authors[1] and doubtfully included by them in this species has since been interpreted by the present writer as belonging to an immature example of *E. formosus*. In the latter species the denticles along the concave margin of the posterior spine are closely approximated; in *E. maccoyanus* they are widely spaced. The United States National Museum collection contains well-preserved specimens of this form from the St. Louis limestone of Missouri (from the G. Hambach collection). One of the most perfect is catalogued as No. 8094, and shown in plate 7, figure 3.

Genus STETHACANTHUS Newberry.

The spines referred to this genus present some resemblance to those of *Physonemus*, and also, in respect to their elongated inserted portion, to certain species of *Oracanthus*, such as *O. vetustus*, presently to be noticed. The maximum size in this genus appears to have been reached in the species known as *Stethacanthus productus*, from the Keokuk limestone of Iowa, the type and only known example of which is preserved in the collection of the United States National Museum. (Cat. No. 3841.)

Two small-sized spines referable to this genus have recently been described by L. Hussakof[2] from the Waverly of Kentucky under the new specific titles of *S. humilis* and *S. exilis*. They are preserved in phosphatic nodules from one or two localities near Junction City, in Boyle County. It is interesting to compare this occurrence of *Stethacanthus* spines with that of similarly formed spines under precisely the same conditions, within small, hard nodules, in the Caney shale of Oklahoma, at the dividing line between the Mississippian and Pennsylvanian. A portion of such a spine, which cannot be specifically identified with certainty, is among the specimens obtained by Doctor Girty from this horizon, and bears the Museum catalogue number 8110. It is from the locality numbered 6079 in Doctor Girty's Bulletin on the Caney Shale, published by the United States Geological Survey in 1909.

Genus HARPACANTHUS Traquair.

This genus, known hitherto by but a single species, *H. fimbriatus* (Stock), includes small, angularly bent spines, which are best interpreted as frontal claspers corresponding to those of recent male Chimaeroids.

HARPACANTHUS PROCUMBENS, new species.

Plate 7, fig. 1.

Spines resembling those of *H. fimbriatus* but distinguished from them by having a more closely spaced series of conical, recurved,

[1] Pal. Illinois, vol. 6, pl. 22, fig. 3.

[2] Hussakof, L. Descriptions of four new Palaeozoic Fishes from North America. Bull. Amer. Mus. Nat. Hist., vol. 32, 1913, pp. 245-250.

faintly striated denticles, eight in number, extending for a short distance backward from the distal extremity along what corresponds to the antero-inferior margin in the head-spines of modern Chimaeroids; the postero-superior margin opposite the series of recurved denticles gently reflected. A sudden curve in the direction of the spine takes place about midway its length, by which the distal portion of the shaft becomes deflected at right angles from the proximal portion. At the point where the abrupt curvature begins along the antero-inferior margin is seen a prominent semicircular knob-like expansion, which probably served for the attachment of muscles operating to depress the clasper. Surface of spine smooth throughout, but under the lens minute pittings are seen. Cross-section more or less oval, somewhat flattened.

The type and only known example of this species was collected by Dr. G. Hambach in the St. Louis limestone, near St. Louis, Missouri. It was acquired by the United States National Museum a few years ago, and is catalogued as No. 8095.

Genus ORACANTHUS Agassiz.

The spines belonging to this genus often attain a very large size, are much laterally compressed and triangular, rarely elongated and slightly arched; internal pulp-cavity very large, base of insertion usually not very deep, sometimes much extended in horizontal direction. Sides of exserted portion ornamented by large tubercles, with a tendency to become arranged in transverse series, sometimes fused.

ORACANTHUS VETUSTUS Leidy.

Plate 6, fig. 2.

Oracanthus vetustus LEIDY, Proc. Acad. Nat. Sci. Phila., vol. 7, 1856, p. 414, and Journ. Acad. Nat. Sci. Phila., [2] vol. 3, 1856, p. 161, pl. 16, figs. 1–3.—NEWBERRY, Trans. N. Y. Acad. Sci., vol. 16, 1897, p. 285, pl. 22, fig. 3.

The peculiar characters of the much extended base in the spines belonging to this species remained unsuspected until the publication of Newberry's posthumous paper in 1897, in which a single large and nearly complete spine was described and illustrated. In the same article is given a review of the principal literature of the genus, and more complete bibliographical references are brought together in J. W. Davis's monograph on Fossil Fishes of the Carboniferous Limestone (pp. 525–526).

The interesting specimen figured by Newberry was obtained from the Kinderhook limestone near Burlington, Iowa. In the Museum collection are two remarkably perfect specimens from the same horizon at Le Grand, Iowa, one of which is shown in plate 6, figure 2. Some differences are to be noted in the details of ornamentation of the spines that have been referred to this species, but they are not

considered as indicating more than individual variation. The differences will be appreciated from a comparison of the original of our plate 6, figure 2, with the complete specimen figured by Newberry. As regards the nature of the inserted portion, however, the two stand in substantial agreement, both being shallow and greatly elongated. Interesting to observe is the fact that the anterior extremity of the elongated base rises into a tumid "shoulder," recalling the very similar appearance presented by spines of Stethacanthus.

Formation and locality.—Kinderhook limestone (Mississippian); Le Grand, Iowa.

ORACANTHUS TRIANGULARIS, new species.

Plate 5, figs. 5, 6.

Spines attaining to a large size, of triangular cross-section in the distal portion, lateral face broad and triangular, resembling in conformation and size the spines of *Xystracanthys mirabilis* from the Coal Measures, except in being less arcuate, and in having more strongly developed conical denticles along the posterior margin. Superficial ornament consisting of large tubercles arranged in more or less regular transverse series, many of them fused together, forming discontinuous ridges.

A few spines presenting the above characteristics are contained in the Museum collection, and, although incomplete, are sufficiently well marked to warrant the establishment of a distinct species to receive them. No other spines are known from the American Lower Carboniferous which exhibit the same broad triangular outline and transversely ridged external surface, due to the coalescence of coarse tubercles in fairly regular series. At the same time the distal extremity is triangular and less laterally compressed in cross-section than is true of most species. The style of ornamentation somewhat resembles that of the type-species, *O. milleri*, and the long and tapering *Physonemus*-like spines which Inostranzev has described from the Russian Carboniferous in accompaniment with the teeth of *Polyrhizodus*. A small fragment from the Chester limestone of Illinois, described by St. John and Worthen as *Oracanthus rectus*, shows a tendency of the tubercles of the exserted portion to become fused into irregular transverse series. The same authors also figure the distal portion of a triangular spine, possibly belonging to the species under discussion, which they erroneously refer to *O. vetustus*.[1] In *O. milleri* the series of ornamented ridges extend obliquely over the sides of the exserted portion.

Formation and locality.—St. Louis limestone, near St. Louis, Missouri. (Cat. No. 8377, U.S.N.M.)

[1] Pal. Illinois, vol. 7, 1883, pl. 24, fig. 2.

Genus EDESTUS Leidy.

Through fortunate discoveries in this country and abroad, our knowledge of the peculiar structures known as the Edestidae has been largely augmented during recent years, and the number of described species increased to more than a score. A review of the existing literature was published by the present writer in 1903,[1] and, a decade later, a further review was contributed by A. Karpinsky,[2] former Director of the Russian Geological Survey. In the same year appeared an important article by O. P. Hay,[3] in which a specimen named by him *Edestus mirus* was declared to afford conclusive proof as to the dental nature of the much-debated segmented structures. This specimen is noteworthy also for having associated with it in the same block of matrix two *Orodus*-like teeth, thus suggesting that the segments of *Edestus* and related genera (*Toxoprion*, *Lissoprion*, *Helicoprion*) were in reality the fused symphysial teeth of Palaeozoic Cestraciont sharks. More recent contributions to our knowledge of this class of remains are two papers by Karpinsky,[4] one on the general nature of *Helicoprion*, the other describing a new species and a preliminary account of Edestus by Woodward.[5]

EDESTUS HEINRICHI Newberry and Worthen.

Plate 6, fig. 1.

Edestus heinrichi NEWBERRY and WORTHEN, Pal. Illinois, vol. 4, 1870, p. 350. pl. 1. fig. 1.

One of the largest and best preserved examples of this species has recently been added to the United States National Museum collection, and catalogued under the number 8032. It was collected a number of years ago by Mr. William Metcalf from the Coal Measures of Appanoose County, Iowa, and by him presented to the National Museum in 1914. Its total length is about 33 cm, and the number of segments indicated by separate teeth and sheaths is ten. Besides these, an eleventh and youngest formed segment, not yet consolidated with the fused mass at the time of the creature's death, when it became lost, is indicated by a smooth area on either face of the posterior half of the common base, where the newly formed

[1] Mark Anniversary Volume, pp. 279–289. New York, 1903.

[2] Karpinsky, A. On Helicoprion and other Edestidae: Verh. Kais. Min. Ges. St. Petersb., vol. 49, 1912, pp. 69–94.

[3] Hay, O. P. On an important specimen of *Edestus*, etc. Proc. U. S. Nat. Mus., vol. 42, 1912, pp. 31–38, pls. 1, 2. See also the following by the same author: On the nature of *Edestus* and related genera, with descriptions of one new genus and three new species. Proc. U. S. Nat. Mus., vol. 37, 1909, pp. 43–61, pls. 12–15. The specimens of *Edestus* described in these papers by Doctor Hay are now preserved in the collection of the United States National Museum. They include the types of *Edestus crenulatus*, *E. serratus*, *E. mirus*, and *Lissoprion ferrieri* Hay.

[4] Karpinsky, A. Notice sur la nature de l'organe hélicoïdal du Helicoprion. Bull. Soc. Ouralienne Sci. Nat. d' Ekatérinebourg, vol. 35, 1915, pp. 117–145. (Text in Russian and French)—A new species of Helicoprion (*H. clerci*). Bull. Acad. Imp. Sci. St. Pétersb., vol. 35, 1916, pp. 701–708. (Text in Russian.)

[5] Woodward, A. S. A new species of Edestus from Yorkshire. Nature, vol. 98, 1916, pp. 102–103.

sheath enveloped the immediately preceding segment. A specimen closely rivalling the one here figured in size and perfection of preservation, but showing a series of nine teeth instead of ten, has recently been acquired by the American Museum of Natural History.

TELEOSTOMI.

Order CROSSOPTERYGII.

The larger number of remains of "fringe-finned ganoids" belonging to the United States National Museum collection consists of Rhizodont scales (14 of them being types described by Cope and others), small Coelacanths, and more or less complete skeletons of Palaeoniscids, all preserved within concretions from the well-known Mazon Creek locality in Grundy County, Illinois. Most of these nodules were formerly contained in the Lacoe collection, acquired by the Museum about twenty years ago. The Lesquereux collection was especially rich in fossils from the Coal Measures of Linton, Ohio, and most of the fishes from this locality are Coelacanths. The so-called ichthyic genus and species, *Mycterops orcinatus* Cope[1] from the Coal Measures of Beaver County, Pennsylvania, is not of vertebrate nature, but founded upon arachnid fragments. The type is catalogued as No. 1977, and another specimen identified as a jugular plate of Coelacanthus by Jaekel, is catalogued as No. 1975.

Family COELACANTHIDAE.

Genus COELACANTHUS Agassiz.

The earliest known representative of this genus is a small form occurring in the basal member of the Upper Devonian near Gerolstein, in Rhenish Prussia, first described by the late Prof. A. von Koenen[2] in 1895, and recognized as a true Coelacanth by Smith Woodward[3] in 1898. A single species, *C. welleri*, has been described by the present writer from the base of the Kinderhook limestone near Burlington, Iowa, and two species of this and a peculiar allied genus, *Palaeophichthys*, have been made known from remains preserved in nodules found at the famous Mazon Creek locality in Illinois.

In the Palaeontology of Ohio (vol. 1, 1873) twenty-seven species of fossil fishes are described from the Coal Measures of Linton, Ohio, and among the number are three belonging to the genus *Coelacanthus*. It is stated by Newberry[4] that the second most abundant species

[1] Amer. Naturalist, vol. 20, 1886, p. 1029.

[2] Koenen, A. von. Ueber einige Fischreste des norddeutschen und böhmischen Devons. Abhandl. Ges. Wiss. Göttingen, phys. Cl., vol. 40, 1895, p. 28.

[3] Woodward, A. S. Note on a Devonian Coelacanth fish. Geol. Mag., vol. 5, 1898, p. 529.

[4] Newberry, J. S. The Paleozoic Fishes of North America, Monogr. U. S. Geol. Survey, vol. 16, 1889, p. 213.

occurring at this locality is *Coelacanthus elegans;* and this author remarks:

> While perhaps a thousand specimens more or less perfect have been taken from one coal mine there, with the exception of a single one found at Morris (Illinois), no representative of this world-wide genus has been elsewhere seen in America

At the conclusion of the volume just cited Newberry records this additional observation in regard to *Coelacanthus ornatus:*

> This is a small species found at Linton, Ohio, where it is very rare. It is briefly described in the Palaeontology of Ohio, vol. 1, p. 340. Since the publication of that volume I have obtained several other specimens and find that it may be readily identified by its small size, relatively large cranial tubercles, and very thin, delicate scales on which the raised lines are parallel and do not converge as in *C. elegans* and *C. robustus.*

Again, at page 215 of the same work, the author remarks:

> Since the notice of the Mazon Creek fishes was published in the report of the Illinois Geological Survey I have received from there a single specimen each of *Eurylepis* and *Coelacanthus,* probably not distinct from those found at Linton.

It thus appears from the writings of Newberry that among the large number of Mazon Creek nodules examined by him, only a single specimen of Coelacanthus came under his observation, and that he identified as belonging to *C. elegans.* An allied small species was described by the present writer in 1903, and a supposed new form of large size has recently been discovered by Prof. E. H. Barbour in the Coal Measures of Nebraska.

COELACANTHUS ELEGANS Newberry.

Plate 9, figs. 5, 6; plate 11, figs. 3, 4.

Probably to this species should be referred a half dozen specimens in the United States National Museum collection, all much distorted and imperfect, but agreeing in scale characters and details of ornamentation of cranial plates with *C. elegans.* The fact that Newberry recognized the occurrence of this species at the Mazon Creek locality increases the probability that we have really to do with a form already known from Linton, Ohio, instead of with an undescribed representative of the genus. The specimens figured in the accompanying plates are catalogued under the following numbers, 4381, 4383, 4405, 4438.

Formation and locality.—Coal Measures, Mazon Creek, Illinois.

COELACANTHUS EXIGUUS Eastman.

Plate 10, fig. 1.

Coelacanthus exiguus EASTMAN, Journ. Geol., vol. 10, 1902, p. 538, text fig. 3; Bull. Mus. Comp. Zool., vol. 39, 1903, p. 189, pl. 5, fig. 48.

This is a small-sized species, none of the known examples exceeding 5 cm. in total length. The type and nine other specimens are

preserved in the Peabody Museum; a single specimen is found in the Museum of Comparative Zoology at Harvard College, and two others, both in counterpart and very well preserved, are the property of the United States National Museum. They were formerly in the Lacoe collection, and one of them bears an original label in Newberry's handwriting which reads: "*Palaeoniscus gracilis* New." It is catalogued as No. 4398, and is the original of our plate 10, figure 1. Whereas in the type-specimen only about nine caudal fin-rays are to be counted above and below, this specimen shows at least thirteen in the lower lobe.

Formation and locality.—Coal Measures; Mazon Creek, Illinois.

Genus PALAEOPHICHTHYS Eastman.

This peculiar crossopterygian genus has been provisionally referred to the Coelacanthidæ, but is distinguished from all other members of the family by its elongate, anguilliform body and continuous median fins. In the latter respect an agreement is to be noted with the specialized and problematical genus *Tarrasius*, from the Lower Carboniferous of Scotland, and also with *Conchopoma gadiforme* Kner, from the Lower Permian of Rhenish Prussia. Possibly both *Tarrasius* and *Conchopoma* should be regarded as aberrant Coelacanths.

PALAEOPHICHTHYS PARVULUS Eastman.

Plate 10, fig. 2.

Palaeophichthys parvulus EASTMAN, Ann. Rept. Iowa Geol. Surv., vol. 18, 1908, p. 253, fig. 37.

This is a very small species, attaining a total length of about 5 cm., with a remarkably short head and slender, elongated, anguilliform body. The median fins are continuous, the dorsal arising behind the occiput at a distance equal to about one-and-one-half times the length of the head itself, and the origin of the anal not far behind the middle of the body.

Besides the holotype of this interesting small species, but a single example has come under the writer's observation. It is a specimen formerly in the Lacoe collection, now the property of the United States National Museum, and catalogued as No. 4453. The nodule in which it is contained would seem to have been fractured by natural means and to have been exposed to atmospheric agencies for a considerable time, thus permitting oxidation to take place over the surface with consequent obliteration of a good many structural details. Thus, the precise point of origin of the median fins is indeterminable, the head bones are confused, and although the neural and haemal arches are clearly indicated in the anterior half of the trunk, they cease to be visible in the caudal region. Under the lens it is

possible to recognize faint traces of the squamation, the scales appearing to be very small and covered with delicate longitudinal striae. A portion of the lateral line scale-row is indicated by characteristic raised markings in the posterior part of the trunk, but the caudal extremity is not distinctly shown. Apparently the tail tapered gradually to a point, without being produced into a supplementary caudal fin. The sum total of morphological features presented by this peculiar genus and species is of extreme interest.

Formation and locality.—Coal Measures; Mazon Creek, Illinois.

Family PALAEONISCIDAE.

The earliest representative of this family, and of primitive sturgeons generally, is the genus *Cheirolepis*, remarkable for its small-sized squamation. A single species is known from the Devonian rocks of North America, described by Whiteaves as *Cheirolepis canadensis*. Three species of *Palaeoniscus* have also been founded upon isolated scales occurring in the Upper Devonian of New York State. These have been named *P. antiquus* and *P. reticulatus* Williams, and *P. devonicus* Clarke, but they are more properly assignable to *Rhadinichthys*.

Genus RHADINICHTHYS Traquair.

This genus, apparently indicated by isolated scale patches in the Upper Devonian rocks of this country, and represented by several species in the Lower Carboniferous of New Brunswick and the United States, persists as late as the Pennsylvanian in this country. One species, *R. deani*, occurring at the base of the Waverly, is remarkable for having yielded the first information we possess concerning the organization of the brain and internal ear of any fossil fish. Since the beautifully preserved brain structure of this species was first described,[1] similar remains have been found in the Coal Measures near Lawrence, Kansas,[2] and less well-preserved specimens are also contained in the collection of fossils from the Caney shale of Oklahoma, already referred to.

One of the specimens from the latter locality showing the internal structure of the head of a small Palaeoniscid, presumably of *Rhadinichthys*, is catalogued as No. 8111, and another showing the greater part of a dentigerous mandible bears the number 8112.

[1] Ann. Rept. Iowa Geol. Surv., vol. 18, 1908, pp. 266–272.

[2] Twenhofel, W. H., and Dunbar, C. O. Nodules with fishes from the Coal Measures of Kansas. Amer. Journ. Sci., vol. 38, 1914, pp. 157–163. Moodie, R. L. A new fish brain from the Coal Measures of Kansas, with a review of other fossil brains. Journ. Comp. Neurology, vol. 25, 1915, pp. 135–181.

RHADINICHTHYS GRACILIS (Newberry and Worthen).

Plate 9, fig. 4.

Palaeoniscus gracilis NEWBERRY and WORTHEN, Pal. Illinois, vol. 4, 1870, p. 347, pl. 3, fig. 4.

The original illustration of this species, the only one hitherto published, is unsatisfactory in several respects, and the description given is very meager. The distinguishing characters are stated to consist in the smooth rhomboidal scales and remote position of the dorsal and anal fins, which are directly opposed to each other. The illustration which appears in the accompanying plate 9 is reproduced from a photograph of a well-preserved small specimen from the Mazon Creek locality (catalogued as No. 4401). The dorsal, of comparatively few rays, is very remote, and may have been displaced backward by deforming agencies during the fossilization process. The anal comprises 7, and the ventrals 6, well-separated rays. The head parts are not distinctly shown, and the squamation in the anterior part of the trunk has been disturbed. This would seem to be a very rare form in the American Carboniferous. The holotype is preserved in the Peabody Museum of Yale University.

Formation and locality.—Coal Measures; Mazon Creek, Grundy County, Illinois.

Genus ELONICHTHYS Giebel.

An amended diagnosis of this genus has been published by Traquair in his Monograph on the Ganoid Fishes of the British Carboniferous Formations (1877, p. 47). Four species have been described from the Pennsylvanian of the Mazon Creek locality, one of which, *E. peltigerus* Newberry, occurs also at Linton, Ohio. It is not known where the holotype of the latter species is preserved, but the counter-impression of the closely allied *E. hypsilepis* Hay is now the property of the United States National Museum (Cat. No. 4848).

ELONICHTHYS HYPSILEPIS Hay.

Plate 9, fig. 3; plate 10, fig. 3.

Elonichthys peltigerus hypsilepis HAY, Proc. Amer. Philos. Soc., vol. 39, 1900, p. 117, pl. 7.

The material at Doctor Hay's command at the time of establishing this species (regarded by him as doubtfully distinct from *E. peltigerus*) consisted of seven specimens, the most perfect one of which was figured by the author in an excellent photographic reproduction. As contrasted with *E. peltigerus*, Hay noted that in all of the specimens examined by him which were well enough preserved, "the scales in several perpendicular rows just behind the shoulder girdle

are twice as high as long. . . . These high scales gradually become reduced in height, so that those below the dorsal fin are about as high as long."

Doctor Hay remarks further that in his material "the caudal fin is fully one-third the total length of the fish, is deeply forked and has the prolongation of the body covered with pointed scales carried out apparently to its very tip. . . . Along the upper lobe of the tail are numerous striated fulcra. These diminish in height each way from the middle of the lobe." As regards contour of the back the same author observes:

> The body appears to have been somewhat elevated immediately under the dorsal fin, the latter being thus lifted somewhat. The sides of this elevation are covered with two rows, an upper and a lower, of narrow, rather long scales, which are directed parallel with the fin rays.

Probably to this species should be referred two specimens belonging to the United States National Museum collection, which are shown of slightly larger than the natural size in the accompanying plates (pl. 9, fig. 3; pl. 10, fig. 3). The form of body is, however, more slender than in the figured example of *E. hypsilepis* and *E. peltigerus*, and the dorsal and anal fins are relatively less elevated and more triangular. The anal fin-rays decrease more rapidly in depth behind, and there is a wider interval between the anal and caudal fins than is the case in those examples of *E. hypsilepis* or *E. peltigerus* which have come under the writer's observation. There is, however, substantial agreement in the number of rays of all the fins, and such differences as have been noted do not appear to warrant the recognition of a distinct species upon the evidence of these examples.

Formation and locality.—Coal Measures; Mazon Creek.

ELONICHTHYS PERPENNATUS Eastman.

Plate 9, fig. 1.

Elonichthys perpennatus EASTMAN, Journ. Geol., vol. 10, 1902, p. 539, text fig. 4; Bull. Mus. Comp. Zool., vol. 39, 1903, p. 190, pl. 5, fig. 49.

This is a very small species, having a total length of less than 4 cm., of which the head occupies a little less than one-fourth. The fins are extremely well developed, the pectoral unusually long, and anal with much extended base line. The fulcra are minute, scales relatively small, obliquely striated; dorsal ridge scales enlarged

Our knowledge of this gracefully formed and highly ornamented small species has hitherto been confined to the original holotype, now preserved in the Museum of Comparative Zoology at Harvard College. A second example, which seems referable to this species, is that shown in plate 9, figure 1. It is in counterpart, and bears the U.S.N.M. catalogue number 4326. The paired fins have become

lost, together with the greater portion of the caudal, and the recumbent rays of the dorsal have become closely appressed and are in part concealed by matrix. No other examples of this species besides the two that are here mentioned have come to light.

Formation and locality.—Coal Measures; Mazon Creek, Illinois.

Family PLATYSOMATIDAE.

Three species of the genus *Platysomus* have been established upon the evidence of a single specimen each from the Mazon Creek locality, all unsatisfactorily illustrated and described; and a fourth species (*P. palmaris* Cope) has been made known from the Permian of the southern part of Indian Territory. The species founded upon Mazon Creek types have been named as follows: *P. orbicularis*, *P. circularis*, and *P. lacovianus*. The first mentioned of these has been reinvestigated by the present writer and transferred to the genus *Cheirodus*. The holotype of *P. circularis* is preserved in the Museum of Illinois State University at Urbana, and the counter impression of the same specimen in the American Museum of Natural History, labeled in Newberry's handwriting.

Genus CHEIRODUS M'Coy.

In this genus the trunk is rhombic, pectoral fins insignificant, and pelvics absent; the scales are deep and slightly imbricated; margin of mouth toothless, pterygoid and splenial with two denticulated longitudinal ridges.

CHEIRODUS ORBICULARIS (Newberry and Worthen).

Plate 9, fig. 2.

Platysomus orbicularis NEWBERRY and WORTHEN, Palaeont. Illinois, vol. 4, 1870, pl. 3, fig. 1 (no description).

Cheirodus orbicularis EASTMAN, Bull. Mus. Comp. Zool., vol. 39, 1903, p. 193, pl. 5, fig. 52.

It is not known where the holotype of this species is now preserved. A poor figure of this unique specimen was given by the original authors, unaccompanied by any textual description. Upon the evidence of a number of specimens belonging to the Peabody Museum of Yale University, one of which was labeled in Newberry's handwriting as pertaining to this species, an amended definition of it was drawn up by the present writer, which may be here restated:

A small species, attaining a maximum length of about 4.5 cm. Trunk deep, orbicular in outline, the dorsal margin elevated into a prominent peak at about its middle point, and the ventral margin angulated to a somewhat less extent at a point about midway between the branchial apparatus and the narrow caudal pedicle. Facial contour of head steep, cranial plates granulated and striated; the head with opercular apparatus contained about two and one-half times in the total length to the base of the caudal fin. Dorsal and anal fins arising at a considerable distance behind the mar-

ginal peaks, and extending close to the origin of the caudal fin; the latter nearly equilobate, its upper lobe with well-developed fulcra, and its width at distal extremity equalling about one-third the maximum depth of trunk. Dorsal fin with 50 or more rays, caudal and anal each with a somewhat lesser number. (Paired fins not observed.)

Scales ornamented externally with faint longitudinal striae and usually one longitudinal ridge situated near the anterior border of each scale; attached surface coarsely striated, the striae being nearly vertical on the deeper flank scales, but oblique on those situated dorsally and ventrally and in the caudal region. Scales of the anterior part of the trunk arranged in nearly vertical narrow bands, those toward the tail showing a slight downward and backward obliquity, and those at the base of anal fin reflexed forward toward the ventral margin.

A single small specimen, catalogued as No. 4404, fairly well preserved and in counterpart, is contained in the United States National Museum collection (from the R. D. Lacoe coll.). One of the halves of this specimen is shown of the natural size in the accompanying plates, and some of the details, such as scale ornament, lateral line, and minute conical teeth are more clearly seen with the aid of a lens in examining the opposite half, which is not figured. For so small a specimen, the dorsal peak at the middle of the back is very prominently elevated, and the appearances do not indicate that this is merely an immature example of some larger form. An understanding of the conformation of the head parts in this and related forms [1] may be gained from consulting the memoir by Dr. R. H. Traquair "On the structure and affinities of the Platysomidae," published in volume 29, 1879, of the Transactions of the Royal Society of Edinburgh.

Formation and locality.—Coal Measures; Mazon Creek, Grundy County, Illinois.

E. FISHES OF THE TRIASSIC SYSTEM.

For the purpose of the present contribution it is not considered practicable to enter into a lengthy or detailed account of the large store of fossil fishes from Mesozoic and Cenozoic horizons belonging to the collections of the United States National Museum, in view of the fact that the majority of these belong to well-known genera, the anatomical structure of which approaches rather closely to that of modern forms, and the systematic position of which is pretty certainly ascertained. A few general remarks on the collection of post-Palaeozoic fishes as a whole, followed by particular notice of certain new or especially interesting species, will be sufficient for this section of the report.

Triassic fishes are extremely well represented in the Museum collection. From the Triassic rocks of eastern North America very extensive collections were made in the Connecticut Valley region dur-

[1] A restoration of the skeleton of *Cheirodus granulosus* (Young) is given in plate 5, figure 1, of this memoir and one of *Platysomus striatus* Agassiz in plate 6, figure 1.

ing the early nineties by Mr. S. Ward Loper, of Middletown, Connecticut, under the direction of Prof. W. M. Davis; and in particular, the specimens obtained by him from one or two localities near Guilford, Connecticut, deserve notice for the excellence of their preservation, and the clearness with which certain doubtful points in the anatomical structure are revealed. Several typical examples from this locality have been selected for illustration in plates 12 and 13.

A number of fine examples of Semionotid fishes from the Newark system of New Jersey (pl. 12, fig. 3), and a few from the Richmond coal field of Virginia, both of Upper Triassic age, are contained in the collection. An exceptionally perfect specimen of *Semionotus elegans* Newberry (Cat. No. 8109) from Boonton, New Jersey, is shown in plate 15, figure 3. The genus *Dictyopyge*, founded upon a nearly complete fish from the Richmond basin, is invested with some historical interest on account of its having been studied by Charles Lyell, Philip Grey Egerton, and Louis Agassiz during the fourth decade of the last century.[1]

From the Cordilleran region of this country a large quantity of fish-remains, now in the National Museum collection, was obtained by Dr. C. D. Walcott in the years 1879-80, when exploring the Kanab Canon of Utah and Arizona as his first work in connection with the United States Geological Survey. During the past decade some further remains from the Shinarump group of southwestern Colorado have been obtained by Dr. Whitman Cross, who has shown that there are strong reasons for correlating the Triassic portion of this group, as defined by Powell, with the lower part of the Dolores formation of Colorado. In the course of his discussion of the homotaxial relations of this group, Doctor Cross introduces a section in Kanab Valley, Utah, made by Doctor Walcott in 1879, showing the precise position of the beds (Nos. 11 and 13) whence the fish remains were derived. A reptilian fauna occurs in the Shinarump conglomerate, and the fish beds of the Kanab section occur some hundreds of feet above this member.[2]

Although the fish-remains from this section are extremely fragmentary, it is possible to recognize with certainty the presence of the genera *Lepidotus* and *Pholidophorus;* and on first examining this material the writer concluded from their general aspect that they indicated a foreshadowing of Liassic conditions.[3] During the past year, however, more complete specimens of the genus *Lepidotus* have been studied, the largest and best preserved of which are illus-

[1] Lyell's paper on the coal field of the James River, near Richmond, Va., is found in Quart. Journ. Geol. Soc., vol. 3, 1847. Some interesting correspondence between Lyell and Egerton has recently come to light, and is published in the Annals of the Carnegie Museum (vol. 9, 1914, pp. 139-148).

[2] Cross, W. The Triassic portion of the Shinarump Group. Journ. Geol., vol. 16, 1908, pp. 97-123. A Devonian fish fauna from this region is also mentioned by Dr. Walcott.

[3] Triassic Fishes of Connecticut. Conn. State Geol. Nat. Hist. Surv. Bull. 18, 1911, p. 35.

trated in the figures at the bottom of plates 12 and 13. Although a precise specific determination is impossible, nevertheless a near comparison may be made with the Semionotid form described by Michael as *Prolepidotus gallineki*, from the Upper Keuper of Silesia.[1] (A series of naturally associated Lepidotid scales is shown in plate 10, figure 7.) The character of the Kanab Valley fish-fauna certainly differs markedly from that of the eastern United States, the differences being probably attributable to the different nature of the sedimentation in the two regions.

A very important suite of material from the Trias of South Africa comprising well-preserved specimens of *Semionotus capensis* Woodward is contained in the collection. The anatomical structure of this species has been carefully investigated by the late Dr. E. Schellwien.[2] Finally, mention should be made of a small but interesting collection of fossil fishes from the Hawkesbury Series at Gosford, New South Wales, one specimen among the number being a peculiar form of *Belonorhynchus*, presently to be described. The ichthyic fauna of this formation has been investigated principally by Dr. A. S. Woodward.[3]

Family CATOPTERIDAE Woodward.

This family comprises Triassic fusiform fishes resembling Palaeoniscids in general structure, but having an abbreviate heterocercal tail, and lepidotrichia which only slightly exceed the radials in number. The latter also appear to be formed chiefly of one proximal segment. The ganoid scales are rhombic; the teeth slender and conical.

The family is accompanied in the Trias by other chondrosteans which became eel-shaped (*Belonorhynchidae*) and died out during that period. Still others, which gradually lost their scaly covering and head bones (*Chondrosteus*) continued to survive, and are represented by the sturgeons of the existing fauna. The relations of this family are, therefore, with modern sturgeons rather than with the two surviving genera of Protospondyli, *Amia* and *Lepidosteus*.

Genus CATOPTERUS Redfield.

The type-species of this genus, *C. gracilis*, was described by J. H. Redfield in 1837. A decade later the second known species of *Catopterus* was described by Sir Philip Grey Egerton, when the new genus *Dictyopyge* was established by him upon the evidence of fairly well preserved specimens from the Richmond coal field of Virginia.

[1] Michael, R. Ueber eine neue Lepidosteiden-Gattung aus dem oberen Keuper Oberschlesiens. Zeitschr. Deutsch. Geol. Ges., vol. 45, 1893, pp. 710-729.

[2] Schellwien, E. Ueber Semionotus Ag. Phys-ökon. Ges., Königsberg, 1901.

[3] Woodward, A. S. The fossil fishes of the Hawkesbury Series at Gosford. Mem. Geol. Surv. New South Wales, Palaeont., No. 4, 1890.

CATOPTERUS GRACILIS Redfield.

Plate 12, figs. 1, 2; plate 13, figs. 1, 2.

Catopterus gracilis J. H. REDFIELD, Ann. Lyceum Nat. Hist., N. Y., vol. 4, 1837, p. 37, pl. 1.—NEWBERRY, Monograph. U. S. Geol. Surv., vol. 14, 1888, p. 55, pl. 16, figs. 1–3.—EASTMAN, Conn. State Geol. Nat. Hist. Surv. Bull. 18, 1911.

Among the most instructive specimens that have come under the writer's observation for elucidating the much vexed subject of the cranial osteology of this species and genus, first mention should be made of one of the original cotypes of *C. gracilis*, now preserved in the Peabody Museum at Yale University; and scarcely inferior in importance are several small specimens from the Connecticut Valley region belonging to the United States National Museum. Two of these latter, from Durham, Connecticut, are shown in the accompanying plate 12, and a larger one from Guilford, in plate 13, figure 1. The original of plate 13, figure 2, from the Trias of Durham, Connecticut, is of value for illustrating how the depth of body is apparently increased by accidental crushing prior to fossilization. In this specimen it is easy to distinguish the row of dorsal ridge-scales which has been pushed over to one side and occupies a position at some distance below the upper contour line of the fossil. Examples of mechanical deformation of this kind point to the extreme degree of caution that is necessary in attempting to trace the dorsal and ventral contours of crushed specimens of this and the accompanying genus *Semionotus* in the Triassic rocks of North America.

To speak more particularly of the cranial osteology, it must be admitted that scarcely anything can be added to the facts already known. The bones forming the cranial roof are as a rule firmly coalesced and their sutures concealed by the tubercular ornamentation. Apparently the superior border of the orbits is formed by the large-sized frontals, which are bounded behind by the parietals (the latter separated in the median line by a small-sized supra-occipital) and squamosal. The inferior border of the orbit is formed by the expanded posterior portion of the maxilla, which is of relatively large size and decidedly Palaeoniscid-like in form. This plate bears numerous fine, acutely conical teeth, and there is also present a small dentigerous premaxilla, which is often found detached from the other mouth-parts.

Just how the facial plates are arranged in the space lying between the orbit and shoulder-region (clavicle) is difficult to determine. Newberry's interpretation of the elements covering this area in a single specimen studied by him is open to serious question. At least one postorbital is present in its normal position behind the eye, and there may possibly be another, or suborbital, below it. Behind these plates is the area commonly occupied by the operculum and suboper-

culum, but the preoperculum was probably much reduced and nearly concealed by adjacent elements.

Formation and locality.—Upper Trias; Connecticut Valley and New Jersey.

Family BELONORHYNCHIDAE Woodward.

Of this family of Triassic chondrosteans, only a single genus which is capable of satisfactory definition has hitherto been discovered. This is *Belonorhynchus*, represented by about a dozen species. Under the term of *Saurichthys* Agassiz are provisionally included several species which may be generically identical with *Belonorhynchus*, as suggested by Otto Reis,[1] but for the present, following Woodward's example, it seems preferable to retain the established systematic arrangement.

Two representatives of *Belonorhynchus* have been described by A. S. Woodward from the Upper Trias of Gosford, New South Wales. These have been named *B. gigas* and *B. gracilis*, and differ from other known species in the form of dermal scutes and minor details of the fins and scales. From the same horizon and locality a single very peculiar specimen has been obtained which recalls in some respects, such as body contour and character of the remote dorsal fin, the smaller of these species (*B. gracilis*). But the conformation of the head and obtuse, rounded snout does not agree at all with the features which we are accustomed to associate with members of this genus for the corresponding region; and the specimen in question is clearly anomalous in this regard.

The specimen just referred to belongs to the Museum collection, and is shown in plate 14, figure 3. It is embedded in the same slab of sandstone in which are contained several specimens of *Cleithrolepis*, *Semionotus*, and *Dictyopyge*, the whole block being entered under the catalogue number 1842. Unfortunately the condition of the specimen does not permit of a closer identification than to suggest being included as an aberrant representative of the Belonorhynchidae, with much abbreviated snout. Sutures in the cranial shield are not distinguishable, and it would appear as if the actual bone substance had been fractured and exposed to weathering. Under such circumstances we are not warranted in establishing a new genus or species upon the evidence of the solitary specimen before us, but a figure of it is given in the hope that further enlightenment may be at some later time forthcoming.

[1] Geogn. Jahresb., 1891, p. 149.

Family SEMIONOTIDAE Woodward.

A study of the characters of this family shows that the genera included under it are fully developed Protospondyli, that is to say, they belong clearly to that large group of "ganoid" fishes which flourished chiefly during the Triassic and Jurassic periods, but declined rapidly, and is represented at the present day by only two fresh-water genera, *Lepidosteus* and *Amia*. From what ancient stock the Semionotidae and other Protospondli are descended we do not precisely know, but it may reasonably be inferred that the late Palaeozoic forerunners (*Acentrophorus*, etc.) of the higher suborder were derived from a modified type of chondrostean. Beyond this, when we inquire as to the origin of the Chondrostei themselves, we find but few facts for our enlightenment. Their origin is at least as ancient as that of the "fringe-finned ganoids," but there is as yet no evidence of a genetic connection between the Chondrostei and crossopterygians. Enough, however, has been ascertained to show that already in the Trias and probably even earlier the divergence between chondrosteans and Protospondyli was strongly marked.

SEMIONOTUS ELEGANS (Newberry).

Plate 15, fig. 3.

Ischypterus elegans NEWBERRY, Monogr. U. S. Geol. Surv., vol. 14, 1888, p. 37, pl. 7, fig. 2; pl. 10, fig. 1; pl. 14, figs. 1, 2.

Ischypterus modestus NEWBERRY, Monogr. U. S. Geol. Surv., vol. 14, 1888, p. 38, pl. 9, figs. 1, 3.

The original specimens serving for the establishment of this species are now preserved in the American Museum of Natural History in New York. They are nearly complete fishes, but much crushed, and in becoming flattened their characteristic features have become obscured. A large-sized specimen, 17 cm. in total length, and more perfectly preserved than any other example of this species seen by the writer, is contained in the United States National Museum collection (Cat. No. 8109). It is from the Trias of Boonton, New Jersey, and represented in my plate 15, figure 3.

Genus LEPIDOTUS Agassiz.

Syn. *Prolepidotus* Michael.

Numerous species of this genus have been described, but many are imperfectly known. No indications of the genus have yet been reported from this country, with the exception of certain isolated scales from the Kiowa shales (Cretaceous) of Kansas. The following new species is regarded as standing in close relations with *L. gallineki* (Michael), from the Rhaetic of Upper Silesia.

LEPIDOTUS WALCOTTI, new species.

Plate 12, fig. 4; plate 13, fig. 3.

An imperfectly definable robust species of moderate size, attaining a total length of about 30 cm., and exhibiting similar proportions as in *L. minor* and *L. notopterus;* apparently closely related to the Upper Triassic *L. gallineki.* Scales smooth, thick, deeply overlapping, not serrated; clavicle extremely massive; head parts and paired fins not observed; dorsal with about 15 stout rays. (Cat. No. 8119, U.S.N.M.)

It is to be regretted that no complete individuals of this early representative of the genus have yet been discovered. The examples figured in the accompanying plates are the most perfect which are contained in the collection made by Doctor Walcott during his first work in connection with the United States Geological Survey. Although the collections were made more than 35 years ago by Doctor Walcott, in whose honor I have pleasure in dedicating the species, it does not appear that any other person has obtained fish remains from the Utah Trias, nor has any other species of *Lepidotus* been described from this country.

Although fish remains were found by Doctor Walcott in considerable abundance in the Kanab section, no other fossil vertebrates were noticed by him. Besides *Lepidotus,* the only other genus that can be certainly identified among the remains is *Pholidophorus,* evidently of primitive character. A single saurian tooth, perhaps crocodilian, has also been recognized. This latter is significant in view of the fact that a Triassic saurian fauna has been found on the Little Colorado in Arizona, in the San Juan Valley, Utah, not far from the Colorado River, at various points in southwestern Colorado where Doctor Cross has been engaged in survey work for many years, and in the vicinity of Lander, Wyoming, where Dr. S. W. Williston has made collections. In the opinion of Doctor Cross, as stated to the writer in a personal communication, "the horizon exploited by Williston [1] in Wyoming is the same as that which furnished the vertebrates described by Lucas [2] in Arizona.

The section made by Doctor Walcott in the Kanab Valley, Utah, was first published by Doctor Cross, as already remarked, in 1908. That part of it lying above the Permian is here introduced in order to show the relations of the beds which carry a vertebrate fauna.

SECTION IN KANAB VALLEY, UTAH, MADE BY C. D. WALCOTT, 1879.

Jurassic.

	Feet.
1. White Cliff sandstone, massive, cross-bedded, light gray, broken into five principal belts by horizontal lines of bedding	585

[1] Williston, S. W. Notice of some new reptiles from the Upper Trias of Wyoming. Journ. Geol., vol. 12, 1904, pp. 688-697.

[2] Lucas, F. A. Vertebrates from the Trias of Arizona. Science, vol. 14, 1901, p. 376. A new batrachian and a new reptile from the Trias of Arizona. Proc. U. S. Nat. Mus., vol. 27, 1904, pp. 193-195.

SECTION IN KANAB VALLEY, UTAH, MADE BY C. D. WALCOTT, 1879—continued.

Triassic.

	Feet.
2. Vermilion sandstone; cross-bedded, friable, readily disintegrating, forming the foothills and slope to the more compact sandstones at the northern end of Vermilion Cliff Canyon	650
3. Gray and reddish-brown cross-bedded sandstone. Horizontal beds of varying thickness divide the mass into bands of from 25 to 100 feet in thickness	300
4. Evenly bedded red sandstones; upper portion an indurated, dark reddish-brown stratum; indurated layers alternate with more friable layers and shales beneath	120
5. Massive gray sandstone, cross-bedded; upper portion is a light-gray massive friable bed. The entire mass is subdivided into six principal beds by subhorizontal lines of bedding of a dark, more indurated sandstone. The beds are from 20 to 80 feet in thickness, and may be seen on many steep escarpments along the canon	310
6. Solid, partially cross-bedded sandstone, changing from gray to various shades of red	20
7. Evenly bedded, light-red sandstone with a thin layer of intercalated gray sandstone	20
8. Dark-red sandstone; massive layers alternating with shale, which disintegrates and forms a sloping talus to the gray sandstone beneath	180
9. Light-gray sandstone	5
10. Bedded sandstone of various shades of red and gray. The layers of sandstone and their shaly partings are irregular in thickness. Scolithus borings occur in great numbers in a friable yellow sandstone. Fragments of vegetable matter and carbonized wood also were seen	230
11. Thin layers of sandstone, alternating with bands of fine argillaceous shale holding fish teeth and shells	25
12. Massive light-brown sandstone, broken up into thick layers	50
13. Alternating layers of sandstone and fine argillaceous shales with fish teeth, etc.	25
A detailed section of 13 is as follows:	
a. Light sandy layers with shaly partings	7
b. Fine, smooth, arenaceous and argillaceous shales, drab brown to red with fillets of green. A few fish scales were found	6
c. Fine-grained, light-colored sandstone, 2 to 4 feet in thickness	4
d. Same as (*b*), only more fossiliferous	8
14. Reddish-brown friable sandstone, broken into layers 1 to 6 feet thick, with shaly partings	120
15. Alternating bands of marls and shales, with layers of friable light and reddish-brown sandstone	70
16. Reddish-brown sandstone broken up into layers 2 to 7 feet in thickness with a stratum of gray sandstone at the base	20
17. Arenaceous and earthy gypsiferous shales; marlites, purple, brown, bluish-green, and green, forming low, rounded foothills and slopes from the Vermilion cliffs to the Shinarump conglomerate	650
18. Gray conglomerate and sandstone. Conglomerate formed of small, agatized pebbles and holding silicified wood	50
Total of Triassic	2,845

F. FISHES OF THE JURASSIC SYSTEM.

There are a number of well-preserved specimens of ganoid fishes in the collection from the Lias of Lyme Regis, Dorsetshire, the Lias of Holzmaden, Württemberg, the Upper Jurassic Lithographic limestone of Solenhofen, and a few types, chiefly of *Pholidophorus*, described by the present writer from the Jurassic of the Black Hills, South Dakota. Some of the larger and more interesting specimens from Solenhofen (*Squatina*, *Gyrodus*, *Aspidorhynchus*, etc.) are to be seen on exhibition in the hall of fossil vertebrates.

In contrast to the large and attractive specimens of the usual type with which we are familiar from the Solenhofen locality, two small forms, evidently juvenile, call for special notice, being in each case the only known example of the young of the species represented. These are described in the following paragraphs.

Family ASPIDORHYNCHIDAE.

The most recent discussion of the structural organization of typical members of this family is that of Paul Assmann, in the first volume

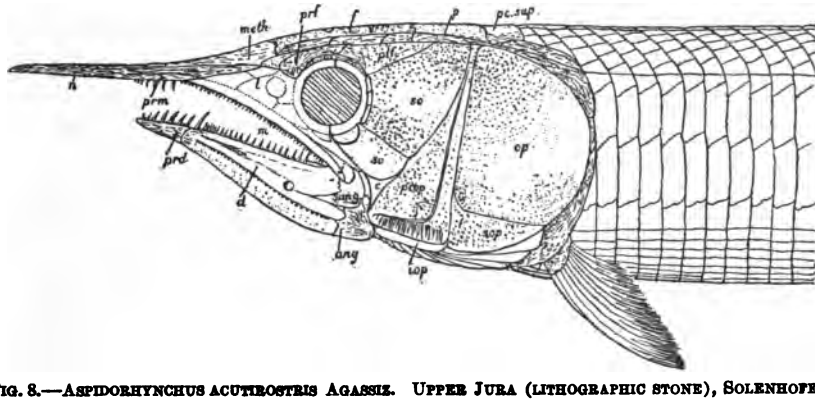


FIG. 8.—ASPIDORHYNCHUS ACUTIROSTRIS AGASSIZ. UPPER JURA (LITHOGRAPHIC STONE), SOLENHOFEN, BAVARIA. LATERAL ASPECT OF CRANIUM, ×½ (AFTER P. ASSMANN. *ang*, ANGULARE; *d*, DENTARY; *f*, FRONTAL; *iop*, INTEROPERCULUM; *j*, JUGAL; *l*, LACHRYMAL; *m*, MAXILLARY; *meth*, MESETHMOID; *n*, ROSTRUM; *oc. sup.*, SUPRAOCCIPITAL; *op*, OPERCULUM; *p*, PARIETAL; *prd*, PREDENTARY; *prf*, PREFRONTAL; *prm*, PREMAXILLARY; *ptf*, POSTFRONTAL; *prop*, PREOPERCULUM; *sang*, SURANGULARE; *sop*, SUBOPERCULUM.

of Archiv für Biontologie, 1906 (pp. 51–79). It deals chiefly with the type species, *A. acutirostris* Agassiz (text fig. 8). The anatomy of the allied genus *Belonostomus* has been carefully investigated by Dr. Benjamin Vetter[1] and some well preserved examples belonging to the Carnegie Museum have recently been figured by the present writer.[2]

[1] Vetter, B. Die Fische aus dem lithographischen Schiefer im Dresdener Museum. Mittheil. Kön. Mineral.-Geol. Præhist. Museum Dresden, pt. 4, 1881.

[2] Memoirs Carnegie Museum, vol. 6, Nos. 6 and 7, 1914–15. The plates for these two publications, and also those for Memoir No. 5 of the same volume, were printed without proofs having been submitted to the author; and in the case of one of the illustrations, that of *Squatina minor*, the original drawing, which is misleading, was not prepared under his direction.

Genus BELONOSTOMUS Agassiz.

BELONOSTOMUS TENUIROSTRIS (Agassiz).

Plate 14, fig. 2.

Aspidorhynchus tenuirostris AGASSIZ, Poiss. Foss., vol. 2, pt. 2, 1833, pp. 14, 143, 297.

Belonostomus tenuirostris WAGNER, Abh. Bayer. Akad. Wiss., Math.-Phys. Cl., vol. 9, 1863, p. 691.—VETTER, Mittheil. K. Min.-Geol. Mus. Dresden, pt. 4, 1881, p. 85.—EASTMAN, Mem. Carnegie, Mus., vol. 6, 1914, Nos. 6, 7.

The beautifully preserved example shown in plate 14, figure 2, is of interest for displaying an early growth stage in the young of this species. Its total length being a trifle under 14 cm., it is much the smallest individual yet recorded. The rostrum appears relatively longer than in the adult, and extends for a relatively greater distance in advance of the presymphysial bone; thus proving that in this species, as is also true for *Aspidorhynchus*, the snout and mandible attain their full development at an early stage, subsequently increasing only in thickness. This condition was first noted by Vetter in the type species of *Aspidorhynchus*, and his observations on the jaws of that form are of sufficient interest to be quoted in this connection:

Der Oberkiefer (mit Rostrum) ist hier wie dort aus denselben Elementen zusammengesetzt und im ganzen auch ähnlich gebildet, namentlich ist der Ausschnitt (échancrure), in welchen der Unterkiefer hineinpasst und welchen Agassiz ausdrücklich als ausschliessendes Merkmal von Asp. hinstellt, auch bei Bel. vorhanden, wenn auch noch etwas mehr abgeflacht (was namentlich bei *B. münsteri* der Fall zu sein scheint); jedenfalls entsteht er hier wie dort durch das Zusammentreffen von Maxillare und Intermaxillare unter sehr stumpfem Winkel und Ueberlagerung des Vorderendes des ersteren durch letzteres. Dagegen ist das Rostrum bei Asp. stets erheblich über die Spitze des Unterkiefers hinaus verlängert (beiden jungen Individuen verhält auch die Länge des vorragenden Theils zur ganzen Länge, vom vorderen Orbitalrande angerechnet, wie 2 zu 3, bei den alten wie 1:2,3 bis mindestens 1:2) und dicht vor derselben um ein Viertel seiner ganzen Länge über jene vorragt. Bei Asp. gliedert auch die relativ kurze Spitze des Unterkiefers als Praemandibel ab, bei Bel. läuft sie continuirlich und sehr schlank aus und der obere Unterkieferrand bildet nur eine schwache Vorragung gegenüber dem "Ausschnitt" des Oberkiefers.

In the same connection the author describes the arrangement of scales on the flanks of *Aspidorhynchus*, and compares it with the conditions observed in *Belonostomus*, a character often difficult to trace in actual specimens. We quote also the following paragraphs:

Es erscheint mir somit wohl zulässig, für alle Arten von Belonostomus eine ziemlich gleichartige Form und Anordnung der Schuppen anzunehmen, welche sich wesentlich durch Folgendes auszeichnet: 1) Die Schuppe der Seitenlinie ist durchaus am höchsten. 2) Darüber folgt eine mittelhohe Schuppe von im Groben halbkreisförmigem Umriss. 3) Ueber dieser sitzen nur noch eine oder höchstens zwei kleine dorsale Schuppen. 4) Unter der Seitenlinienschuppe schliesst such eine mittelhohe Schuppe mit beinah horizontalem Unterrand an. 5) Die erster der ausserordentlich niedrigen Ventralschuppen ist besonders hinten etwa doppelt so hoch als die folgenden.

Vergleicht man nun damit die für Aspidorhynchus typischen Verhältnisse, welche aus zahlreichen Darstellungen hinlänglich bekannt sind, so stösst man auf folgende durchgreifende Unterschiede: 1) Die Seitenlinienschuppe erreicht höchstens dieselbe, meistens eine erheblich geringere Höhe als die darunter folgende. 2) Diese schneidet unten wie die erstere mit schiefem Rande ab. 3) Darunter folgt eine mittelhohe Schuppe, deren hinterer Rand in der Regel länger ist als ihr Längsdurchmesser, und nun erst kommen die niedrigen Ventralreihen. 4) Die über der Seitenlinienschuppe stehende Schuppe ist noch ansehnlich hoch und von regelmässigem Umriss. 5) Darüber kommen mindestens 3 Reihen rhombischer, durchweg stark sculptirter Schuppen.

The scale arrangement in the specimen in hand is not clearly displayed. On the other hand the head bones, teeth of the maxillary and mandible, vertebral rings with their fused arches, and all of the fins, are distinctly visible. The dorsal fin comprises at least 10 rays, and the anal a larger number, apparently about twice as many.

Formation and locality.—Lower Kimmeridgian (Lithographic Stone); Solenhofen Bavaria. The figured specimen is catalogued as No. 23.

Genus NOTAGOGUS Agassiz.

This genus closely resembles *Propterus*, but differs in the non-elongation of the anterior rays of the dorsal fin, which are very widely spaced, and in the less deeply forked character of the caudal fin.

NOTAGOGUS MINUTUS, new species.

Plate 14, fig. 4.

Founded upon a very small (5 cm. long), nearly complete fish, in which the proportions of head and trunk are very similar to those (Cat. No. 8379, U.S.N.M.) of *N. inimontis* Thiollière, but with more slender form of body, the two portions of the dorsal less widely separated, each consisting of about nine rays, and posterior border of scales smooth.

This is one of the smallest known species of *Notagogus*, and it is probable that the unique specimen upon which it is founded is an immature individual. At the same time its characters appear tolerably distinct, and as it cannot be identified as the young of any known form we are warranted in describing it as representing a separate species. Another small form accompanying the holotype in the same horizon is the recently described *N. decoratus*, in which the anterior portion of the dorsal comprises about 10 rays, all widely spaced with the exception of the first three. *N. inimontis* is known only from the Cerin locality in the ancient province of Bugey, France.

Formation and locality.—Lower Kimmeridgian (Lithographic Stone); Solenhofen, Bavaria.

G. FISHES OF THE TERTIARY SYSTEM.

A rich assortment of fossil fishes from the Green River Eocene of Wyoming and other western localities is contained in the collection, and among the number are included several important type speci-

mens. From the Miocene of Florissant, Colorado, quantities of *Amyzon* remains, and from corresponding strata in Esmeralda County, Nevada, large numbers of Leuciscus skeletons have been added to the collection. There is also an abundant representation of Eocene and Miocene ichthyic remains from the Atlantic coast region, and from foreign Tertiary horizons mention should be made of a number of fine slabs from the Upper Eocene of Monte Bolca, in northern Italy. In the following pages some of Cope's types which have not previously been figured receive attention, and two or three new species of Tertiary fishes are described.

Family OSTEOGLOSSIDAE.

This family, first appearing in the Eocene, is represented by several modern genera, two of which, *Osteoglossum* [1] and *Arapaima*, are found in South American rivers. *Heterotis* is a tropical African genus. The skull in this group has a distinctly primitive appearance, the superficial bones being thinly covered by skin and having a sculptured surface. The wide nasals, frontals, and parietals meet in the middle line, and the supraoccipital scarcely reaches the surface. Both the premaxilla and maxilla are toothed, and share in forming the margin of the mouth; there is no supramaxilla. The suboperculum is small, often hidden behind the preoperculum, and likewise the interoperculum (Goodrich).

Genus DAPEDOGLOSSUS Cope.

Syn. *Phareodus* Leidy (undefined).

The largest and best known species of this genus is *D. testis* Cope, from the Green River Eocene of Wyoming, of which beautifully preserved specimens exist in the United States National Museum, and in the American Museum of Natural History, New York. One nearly complete skeleton in the latter institution is instructive for having the bones of the skull partly dissociated and displayed to excellent advantage for study. It is catalogued as No. 4587. Through comparison with this specimen it has been possible to identify positively the isolated skull shown in plate 16, figure 1, as belonging to this species. This well-preserved cranium is the property of the United States National Museum (Cat. No. 4916), and has been carefully prepared so as to reveal the underside, freed from the matrix. Its primitive characters are evident, and among surviving genera the resemblance is closest to *Heterotis* of tropical Africa.

[1] For an investigation of the cranial osteology of this genus, see the following: Bridge, T. W. On certain features of the skull in *Osteoglossum formosum*. Proc. Zool. Soc. London, 1895, pp. 302-310.—Ridewood, W. G. On the cranial osteology of the fishes of the families Osteoglossidae, Pantodontidae, and Phractolaemidae. Journ. Linn. Soc. Zool., vol. 19, 1905, pp. 252-282.

Family GONORHYNCHIDAE.

This family, represented in the Upper Cretaceous by *Charitosomus*, and in the middle Eocene by *Notogoneus*, is known to have but one surviving species in the modern fauna. This is *Gonorhynchus greyi*, a specialized form which inhabits the seas off Japan, South Africa, Australia, and New Zealand. It has the head and body covered with small ctenoid scales, and carries a ventral barbel on the prolonged snout. The supraoccipital separates the parietals, the premaxilla

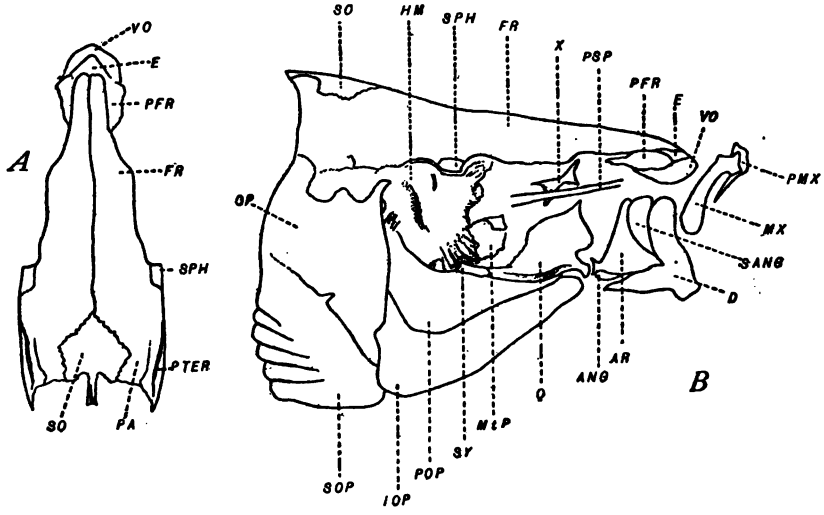


FIG. 9.—NOTOGONEUS OSCULUS COPE. GREEN RIVER EOCENE; TWIN CREEK, WYOMING. DORSAL (*A*) AND LATERAL (*B*) ASPECTS OF CRANIUM, ½. (AFTER L. HUSSAKOF). *ANG*, ANGULAR; *AR*, ARTICULAR; *D*, DENTARY; *E*, ETHMOID; *FR*, FRONTAL; *HM*, HYOMANDIBULAR; *IOP*, INTEROPERCULUM; *MtP*, METAPTERYGOID; *MX*, MAXILLA; *OP*, OPERCULUM; *PA*, PARIETAL; *PFR*, PREFRONTAL; *PMX*, PREMAXILLA; *POP*, PREOPERCULUM; *PSP*, PARASPHENOID; *PTER*, PTEROTIC; *Q*, QUADRATE; *SANG*, SURANGULAR; *SO*, SUPRAOCCIPITAL; *SOP*, SUBOPERCULUM; *SPH*, SPHENOTIC; *SY*, SYMPLECTIC; *VO*, VOMER; *X*, CHEEK-PLATE.

articulates with the maxilla and excludes it from the margin of the small mouth. According to Smith Woodward the members of this family are related to the Scopelidae.

Genus NOTOGONEUS Cope.

Syn. *Protocatostomus* Whitfield.

The type species of this genus is *N. osculus* Cope, from the Green River limestone of Wyoming, in size attaining a length of about 60 cm. The general structure of the head in this species is indicated in the accompanying text-figure 9, taken from L. Hussakof,[1] who combined in the diagram details shown by three specimens preserved in the American Museum of Natural History.

In plate 15, figure 2, is shown a young individual, which is the smallest known belonging to this species. It adds nothing to our

[1] Bull. Amer. Mus. Nat. Hist., vol. 25, 1908, p. 83.

knowledge of the species in displaying characters already observed, but it is interesting for the same reason that the young of other species are interesting to which we have called attention in the present article and figured in plate 14—namely, immature examples of *Belonostomus*, *Notagogus*, and *Acanthurus* (pl. 14, fig. 1) (the last from the upper Eocene of Monte Bolca, Italy). These young individuals acquaint us with early growth stages of the several species in question, and enable us to compare the relative proportions of different parts at different periods in the life history for the species in question. The original of our plate 15, figure 2, is catalogued as No. 6037.

Formation and locality.—Green River Eocene, Wyoming.

Family CYPRINODONTIDAE.

In this family, which includes forms of extremely small size, the mouth is protractile, teeth are present on the jaws and pharyngeals, but rarely on the palate; the palatoquadrate arch is more or less reduced; and the supraoccipital extends forward to the frontals, separating the parietals in the median line. Only two or three extinct genera are known with certainty. Modern forms are mostly confined to fresh waters, but a few are found in brackish water and on the seacoast.

Genus GEPHYRURA Cope.

In July, 1891, E. D. Cope published descriptions of five new species of fossil fishes from a supposed Lower Tertiary horizon in Ree Hills, South Dakota. Three of the forms were regarded as typical of new genera, which were named by the author *Gephyrura*, *Proballostomus*, and *Oligoplarchus;* the taxonomic relations of the first two being with the cyprinodonts, and of the last named with the percoids. The holotypes of these new genera and species are now preserved in the American Museum of Natural History and have recently been studied by the present writer. Although the type of *Gephyrura* was referred by Cope with some hesitation to the cyprinodonts, there does not appear to be the slightest doubt as to the correctness of this association; and the unique specimen available for study evidently stands in close relations with the new cyprinodont genus immediately to be described from the Lahontan beds near Hazen, Nevada. For convenience of referrence, however, we may first restate the specific characters of *G. concentrica*, as defined by Cope.

GEPYRURA CONCENTRICA Cope.

Gephyrura concentrica COPE, Amer. Naturalist, vol. 25, 1891, p. 654.

Char. specif.—The only specimen is broken vertically across the middle, and the posterior half shifted so as to lie immediately below its proper position. It appears that little or no part of the fish has been lost. Radii, P. 9; D. 9; C. 6-16-8; A. II 11.

V. 1–6; vertebrae, 10–18. Scales in twelve longitudinal rows between dorsal and ventral fins, and equal in number to the vertebrae on the longitudinal line, or 28. Head covered with scales; five in a vertical line on the operculum. The dorsal, pectoral, and ventral fins are rather small. The caudal fin is probably not much forked, if at all. The orbit is large, but its outlines are not well preserved. The head enters the total length four and a quarters times to the base of the caudal fin-rays, and slightly exceeds the depth at the ventral fins. Total length, 61 mm.; length of head, 15 mm.; length to base of ventral fin, 24.5 mm.; length to base of anal fin, 30 mm.; depth at ventrals, 14 mm.; depth at caudal peduncle, 6 mm.

Formation and locality.—Oligocene (?) Ree Hills, South Dakota.

PARAFUNDULUS, new genus.

A genus closely related to existing killifishes, and also to the extinct *Gephyrura*, but distinguished from the latter chiefly by its smaller and less conspicuously marked scales, larger number of dorsal fin rays, and presence of a hypural bone. Caudal fin gethyrocercal.

Type of the genus.—*Parafundulus nevadensis*, new species.

PARAFUNDULUS NEVADENSIS, new species.

Plate 16, fig. 2; plate 17; plate 18, fig. 3.

A small form attaining a total length of about 5.5 cm., in which the length of the head and opercular apparatus is contained three and one-half times. Dorsal comprising 11 rays, supported by an equal number of interspinous bones, and inserted opposite a point midway between the pelvics and anal. Scales small and thin, with fine concentric markings, crossed by a few inconspicuous radiating proximal striae.

Fin formula: D. 11; C. 23; R. 10; V. 9; P. 11–12.

The specimen (Cat. No. 8120) selected as type of this species is photographed of the natural size in plate 16, figure 2, and a drawing of it is reproduced in plate 18, figure 3. It is the most perfect of several that were obtained in 1905 by Mr. N. H. Darton, in strata of very white clay near Hazen, Nevada, which have received the name of Lahonton beds. From the same locality a single species of stickleback, known as *Gasterosteus doryssus* Jordan, was described almost simultaneously in 1907 by Drs. D. S. Jordan[1] and O. P. Hay.[2] Besides the type several other examples of this species, shown in plate 17, were collected by Mr. Darton at the same locality, and are now preserved in the collection of the United States National Museum. The writer is indebted to his colleague, Mr. John Treadwell Nichols, of the American Museum of Natural History, for helpful suggestions in regard to comparing this form and its scale characters with the existing *Fundulus*.

Formation and locality.—Lahontan beds; near Hazen, Nevada.

[1] Pub. Univ. Cal., vol. 5, 1907, No. 5, p. 131, figs. 25, 26; Smiths. Misc. Coll., vol. 52, 1910, p. 117.
[2] Proc. U. S. Nat. Mus., vol. 32, 1907, pp. 271–273, figs. 1–3.

Family CYPRINIDAE.

Genus AMYZON Cope.

This is an extinct genus related to modern suckers, but with a more extended dorsal fin. It is stated by Woodward to be "scarcely distinguishable from *Sclerognathus*, but with pharyngeal bones expanded behind." Mr. J. T. Nichols has pointed out to the writer that the Canadian species *A. brevipinne* approaches very closely to existing buffalo fishes of the genus *Ictiobus;* and Cope, in his description of *Amyzon*, has remarked upon its near relations with *Bubalichthys*.

AMYZON BREVIPINNE Cope.

Plate 19, figs. 1, 2.

Amyzon brevipinne COPE, Proc. Acad. Nat. Sci. Phila., 1893, p. 402.—LAMBE, Trans. Roy. Soc. Canada, vol. 12, 1906, pp. 151–155, pl. 1.

The type of this species was obtained from beds in British Columbia supposed to be of late Eocene or early Miocene age. It has never been figured, but one small specimen from Horsefly River, British Columbia, and another belonging to a different species (not of *A. commune*, however), have been described and illustrated by Dr. L. M. Lambe within recent years.

To this species should probably be referred two specimens figured in plate 19, which were collected in 1910 by Mr. J. B. Umpleby from beds of supposed Lower Miocene age, near Republic, Washington. These are now the property of the National Museum, and are catalogued as Nos. 81 and 8117. They are the largest and best preserved examples of this species yet brought to light.

Genus LEUCISCUS Cuvier.

LEUCISCUS TURNERI Lucas.

Leuciscus turneri LUCAS, 21st Ann. Rept. U. S. Geol. Surv., 1901, pt. 2, pp. 223–224, pl. 31.

The holotype of this species (Cat. 4302*a*), and a large number of well-preserved specimens from the Esmeralda formation in western Nevada, are contained in the United States National Museum collection. The age of these beds is discussed by H. W. Turner in the Twenty-first Annual Report of the United States Geological Survey, 1899–1900 (part 2, pp. 203–205), and in the same volume (pp. 209–220) the fossil plants occurring in this formation are described by F. H. Knowlton.

Nothing can be added to our knowledge of the species beyond the information already contributed by Dr. F. A. Lucas.[1] There may be compared with it, however, a specimen that apparently belongs to

[1] 21st Ann. Rept. U. S. Geol. Surv., 1901, pp. 223–224, and Proc. U. S. Nat. Mus., vol. 23, 1900, pp. 333–334, pl. 7.

this or a closely related species, from the Madison Valley, Montana, which is shown of slightly larger than the natural size on plate 18, figure 4. Mr. Earl Douglass, who collected a small number of fish remains from this locality, is of the opinion that the strata containing them is of Oligocene or Lower Miocene age. An undetermined species of *Osmerus* is apparently indicated by the original of plate 18, figure 5, from the same locality as the last. Both are preserved in the Carnegie Museum in Pittsburgh. In plate 19, figure 3, is shown an example of an undetermined cyprinodont species from the Tertiary of Mexico.

Family SILURIDAE.

Fossil representatives of this family are uncommon, and for the most part imperfectly preserved. Fragmentary remains from the Lower Eocene have been assigned to *Arius*, and others from the Lower Miocene to *Ameiurus*. The undermentioned specimen is the only nearly complete example of the latter genus that has been discovered in the fossil state.

Genus AMEIURUS Rafinesque.

AMEIURUS PRIMAEVUS, new species.

Founded upon a unique specimen without locality label, but as far as may be judged from the appearance of the matrix it would seem to have been derived from the Green River Eocene of Wyoming. Clearly related to the more generalized and representative genus of modern North American catfishes *Ameiurus*, it differs from all living species in its shorter anal, consisting of only 12 rays, and in this respect resembles the more specialized genus *Leptops*, known by a single species. It is shown in plate 20.

The holotype of this species is a nearly complete skeleton having a total length to the base of the caudal fin of 21.5 cm., in which the length of the head including the supraoccipital process is contained three times. Head broad behind, not much contracted forwards; surface sculpture consisting of anastomosing rugae and pittings as in the recent *A. catus;* orbits small; fontanelle situated just before the origin of the supraoccipital process. Maximum breadth of head in its flattened condition equal to its length. Vertebrae 29 in number, with strong neural spines. Dorsal fin between the pectorals and ventrals, with about six branched rays of moderate length (its spine broken away). Pectoral spines strong, smooth, less than half as long as the head. Ventrals with eight, anal with apparently not more than twelve rays. Rays of caudal fin mostly broken away, but the curved line formed by their articulation with hypural fin-supports indicating that the fin was rounded. (Cat. No. 8122, U.S.N.M.)

This is an extremely interesting and well-preserved specimen, save that the caudal fin is for the most part lacking, and the dorsal has been folded under the neural spines and partly concealed by them.

The supraoccipital process has been shifted slightly to one side of the anterior vertebrae, and was apparently not in direct connection with them. The relations are evidently very close with the existing *A. catus*, excepting as regards the smaller number of anal fin rays and nonserrate character of the pungent pectoral spines. With respect to the short-based anal fin, it may be said that although only a dozen rays are now visible in the specimen, a few more may have been present in advance of those now to be seen, but became lost or were cut away by careless trimming of the specimen along the ventral margin. In fact, one can almost certainly distinguish, although faintly, traces of a few interspinous bones in advance of the foremost anal fin ray now appearing in the specimen. At the most, however, we must admit that this fin was shorter than in existing species of *Ameiurus*, but otherwise the differences are of but minor character.

The latter observation appears the more remarkable if we accept the view as correct that the fossil before us is of Middle Eocene age. How closely *Rhineastes*, from the Green River Eocene, agrees structurally with modern species of Silurids, cannot be determined, as it is known only by fragmentary remains. But in the nearly complete skeleton which we are now considering we find evidence that the typical expression of the genus *Ameiurus*, as we know it to-day, was already attained in the early Tertiary, and has persisted unchanged ever since.

Formation and locality.—Supposedly from the Green River Eocene of Wyoming.

Family PERCIDAE.

This family and the small one known as Aphredoderidae, now nearly extinct, are included in Doctor Gill's superfamily Percoidea. The types of most of Cope's species of *Amphiplaga*, *Asinepos*, *Erismatopterus*, and *Trichophanes*, belonging to the Aphredoderidae, are preserved in the collection of the United States National Museum. The nearly complete example of *Trichophanes foliarum* Cope, which has recently been figured by T. D. A. Cockerell,[1] is the property of the American Museum of Natural History, and the types of Cope's species of *Mioplosus* are divided between this institution and the National Museum.[2]

Fossil perches in the restricted sense of the term are represented in the Tertiary rocks of this country by the genera *Mioplosus*, *Plioplarchus*, and *Oligoplarchus*. The first of these differs from *Perca* in having fewer vertebrae and a spineless operculum. It is known by several species in the Green River Eocene, of which the genotype, *M. labracoides* Cope, is the most common. Probably the so-called *M.*

[1] Amer. Naturalist, vol. 42, 1908, p. 571.

[2] For lists of specimens see the published catalogues of type and figured specimens belonging to these museums, already referred to. The parts dealing with fishes were published in 1907 and 1908, respectively.

longus is only a young example of this form, the individuals of which show a considerable amount of variation. In plate 21 is shown a large (44 cm. long) and well-preserved specimen which may be referred to *M. labracoides*, notwithstanding the fact that it displays one abdominal and one caudal vertebra in excess of the normal number occurring in the type-species. The type of *M. multidentatus* Cope has not been figured. It is preserved in the American Museum of Natural History.

Formation and locality.—Green River Eocene; Wyoming.

Genus PLIOPLARCHUS Cope.

This extinct genus, closely related to *Mioplosus*, is represented by three Lower Tertiary species, of which only one, *P. whitei* Cope, has been illustrated. The differences between this species, which is the type, and *P. sexspinosus*, are stated to consist in the more numerous spinous, and less numerous soft rays, of the dorsal and anal fins. In *P. whitei* the radial formula is:

D. IX–12; C.–17–; A. V–14; V. ?; P. 13.

And in *P. sexpinosus* it is:

D. X–13; C. –17–; A. VI–9.

In *P. septemspinosus* the formula is given as:

D. XI–?; A. VII (?)–12.

PLIOPLARCHUS SEXSPINOSUS Cope.

Plate 15, fig. 1.

Plioplarchus sexspinosus COPE, Amer. Journ. Sci., vol. 25, 1883, p. 416; Rept. U. S. Geol. Surv. Terr., vol. 3, 1884, p. 729.

In the original description it is stated that "this species is represented by two specimens, both of which lack the head and body anterior to the dorsal fin." These specimens are now in the United States National Museum collection, and one of them, marked "type," is catalogued as No. 4236. It is from the Lower Tertiary, perhaps Miocene, near Sentinel Butte, in Billings County, North Dakota. A much more complete example, also from the type locality, is shown in our plate 15, figure 1. In it the anal fin is seen to have six spinous and twelve soft rays. The specimen bears the catalogue number 8118.

Formation and locality.—Miocene (?); top of Sentinel Butte, North Dakota.

PLIOPLARCHUS SEPTEMSPINOSUS Cope.

Plate 22.

Plioplarchus septemspinosus COPE, Amer. Naturalist, vol. 23, 1889, p. 625.

This species was established by Cope upon the evidence of four distorted and mutilated specimens from shales near Van Horn's ranch, on the John Day River, Oregon, the strata whence they were

obtained being supposed by Cope to be approximately equivalent to the Amyzon beds. The specific characters are thus diagnosed by the author:

The mouth is small, and opens obliquely upward. Premaxillary and dentary teeth in several rows. Size larger than that of the *P. whitei* Cope, and the scales are less numerous and of larger size. The spinous rays are less numerous than in that species and the *P. sexspinosus*. Formula: D. XI.—?; A. VII—? 12; the soft anal rays at least 12, possibly more. Scales in five or six rows above the vertebral column and in 10 or 12 below it. Radiating ridges of proximal portion strong; disk and distal portion scarcely roughened. Caudal vertebrae, 15.

The specimens are all too much injured to permit of complete measurements. The largest measures from the end of the muzzle to the base of the caudal fin 260 mm., and 90 mm. in depth at the vertical fins. The last dorsal spine measures 36 mm. A lateral dorsal scale is 6 mm. in length.

Family CICHLIDAE (Chromidae).

Known in the fossil state by a single Eocene genus, the numerous modern forms are tropical and subtropical fresh-water fishes. There is no ingrowth from the suborbitals forming a suborbital shelf, no supramaxilla, and a suture divides the lower pharyngeals.

Genus PRISCACARA Cope.

This, the only known fossil genus, differs from all existing members of the family in the possession of vomerine teeth. Small, conical teeth are present along the margin in both jaws, and the preoperculum is serrated. According to Haseman,[1] there are six branchiostegal rays.

Of the seven species which have been described by Cope from fresh-water Tertiary formations in this country, the types of six are preserved in the United States National Museum. These species, according to Cope, fall into two sections. "In the first," he writes, "the ventral spine is very strong, and there are but 10 or 11 soft dorsal radii: here belong *P. serrata*, *P. cypha*, *P. oxyprion*, and *P. testudinaria*. In the second, the first ventral spine is weak and slender, and there are 13 or 14 radii of the second dorsal fin; in this division belong *P. liops*, *P. pealei*, and *P. clivosa*.

PRISCACARA DARTONAE, new species.

Plate 23.

A species of large size, attaining a total length of 28 cm. to base of caudal fin, in which the length of the head and opercular apparatus is contained two and three-fourths times. Maximum depth entering into total length 2.7 times. Dorsal contour strongly arched and frontal profile rising steeply to a point just in front of the origin of the dorsal fin; the vertebral column arched anteriorly so as to be directed

[1] Haseman, J. D. The relationship of the genus Priscacara. Bull. Amer. Mus. Nat. Hist., vol. 31, 1912, pp. 97–101.

nearly parallel to the dorsal contour. Spinous rays of all the fins relatively weaker than in other known species, those of the dorsal fin not quite equalling the soft rays in length; pectoral fin rays when appressed against the ventral margin reaching to the anal; the latter having the second and third spines about equally developed. Vertebrae: 10 abdominal, and 15 caudal. Radial formula:

D. XI.–11; A. III.–8; V. I–5.

The holotype upon which this species is founded is a large (35 cm. long) and handsome specimen, excellently preserved, and remarkable for its steep facial profile and correspondingly increased depth of body as compared with other species. The vertebral column is also prominently flexed anteriorly, and the number of vertebrae is greater than in related species. The number of spinous rays in the dorsal fin is also greater by one than in either *P. serrata* or *P. oxyprion*, and the the number of rays in the anal fin the same as in these species. The spinous rays of all the fins are less robust than in any described species, and those of the dorsal fin are relatively shorter. In form of body this species stands in rather close agreement with *P. clivosa* Cope, which is smaller, and differs in fin characters and number of vertebrae. In other respects the new species shows considerable resemblance to *P. oxyprion*, in particular the number of anal and pelvic fin-rays being the same. One may say that it is intermediate in respect to the majority of its characters between these two species, *P. oxyprion* and *P. clivosa;* and although attaining as large a size as the type-species, *P. serrata*, it is much less formidably armed. Correlating with a weaker defense, it was probably of less active habits.

The writer takes pleasure in naming this species in honor of his friend, Mrs. N. H. Darton, of Washington, who with her husband has collected fish remains from western Tertiary horizons. (Cat. No. 2381, U.S.N.M.) To Mr. Darton the writer is indebted for the opportunity of studying the remains collected from near Hazen, Nevada (see p. 291, under *Parafundulus*) and from the Black Hills uplift of South Dakota.

Formation and locality.—Green River Eocene, near Fossil, Wyoming.

UNCERTAIN PLACE.

Genus ISCHYRHIZA Leidy.

The peculiar teeth first described by Leidy from the Cretaceous of New Jersey under this name, and since found in the Eocene of the Atlantic Coast region and in the Fox Hills Cretaceous of New Mexico, were conjectured by Cope to have belonged to teleost fishes, allied to the Esocidae. He also proposed that certain coalesced caudal vertebrae ("hypural fans") accompanying the Cretaceous teeth and occurring also in the Eocene of Maryland and South Carolina, should

be theoretically associated with the same genus. A somewhat different view has been expressed by the present writer,[1] who suggests that the Cretaceous fans may have belonged to *Protosphyraena* or some similar form, and that the Tertiary fans, which differ from the Cretaceous in having the terminal centrum attached, properly belong to swordfishes.

In accordance with this latter interpretation, the large fan which is shown in plate 16, figure 3, from the Phosphate Beds of South Carolina, may be provisionally assigned to *Xiphias*, and the detached tooth of *I. mira* Leidy shown in plate 11, figure 2, from the Ripley Group (Cretaceous) near Dumas, in Tippah County, Mississippi, should be assigned to a different taxonomic position. Cope's conjecture that the teeth of *Ischyriza* indicate affinity with the Esocidae is accepted by O. P. Hay and others, and seems plausible. The type of *I. mira*, together with other specimens from New Mexico, are preserved in the American Museum of Natural History

EXPLANATION OF PLATES.

PLATE 1.

Heteracanthus uddeni Lindahl, p. 245.

Head-spine, natural size. Devonian (Cedar Valley limestone); Johnston County, Iowa.

PLATE 2.

FIG. 1. *Dinichthys tuberculatus* (?) Newberry, p. 249.

Dorsomedian plate, natural size. Devonian (Chemung); Warren County, Pennsylvania.

FIG. 2. *Sauripterus taylori* Hall, p. 252.

Naturally associated cranial roofing plates, natural size. Devonian (Catskill); near Blossburg, Pennsylvania.

PLATE 3.

Physonemus gemmatus (Newberry and Worthen), p. 263.

Spine, × ⅔. Mississippian (Keokuk limestone); near Keokuk, Iowa.

PLATE 4.

Physonemus gemmatus (Newberry and Worthen), p. 263.

Spine, × ⅔. Mississippian (Keokuk limestone); near Keokuk, Iowa.

PLATE 5.

FIGS. 1 and 2. *Physonemus arcuatus* M'Coy, p. 264.

Two spines natural size. Mississippian (Keokuk limestone); Keokuk, Iowa.

FIG. 3. *Physonemus gemmatus* (Newberry and Worthen), p. 264.

A much weathered, arcuate spine, natural size. Pennsylvanian; near San Saba, Texas.

[1] Maryland Geol. Survey, Eocene, 1901, p. 111. Miocene volume, 1904, p. 93.

FIG. 4. *Ctenacanthus gracillimus* Newberry and Worthen, p. 261.

Spine, natural size. Mississippian (St. Louis limestone); near St. Louis, Mo.

FIGS. 5 and 6. *Oracanthus triangularis*, new species, p. 268.

Spine, natural size. Part of spine? × ⅔. Mississippian (St. Louis limestone); near Alton, Ill.

PLATE 6.

FIG. 1. *Edestus heinrichi* Newberry and Worthen. p. 269.

A large, well-preserved series of fused dental segments × ½.
Pennsylvanian; Appanoose County, Iowa.

FIG. 2. *Oracanthus vetustus* Leidy, p. 267.

Dorsal spine, × ½. Mississippian (Kinderhook); Le Grande, Iowa.

PLATE 7.

Harpacanthus procumbens, new species, p. 266.

FIG. 1. Fin-spine, natural size.
Mississippian (St. Louis limestone); St. Louis, Missouri.

Erismacanthus maccoyanus St. John and Worthen, p. 265.

FIGS. 2, 3. Fin spines, natural size.
Mississippian (St. Louis limestone); St. Louis, Missouri.

Dicrenodus texanus, new species, p. 256.

FIG. 4. Tooth, natural size.
Pennsylvanian; near San Saba, Texas.

Sauripterus taylori (?) Hall, p. 252.

5. (?) Basisphenoid, natural size.
Devonian (Catskill); near Blossburg, Pennsylvania.

Coccosteus, species, p. 246.

6. Antero-ventro-lateral plate, natural size.
Devonian (Elbert formation); near San Juan, New Mexico.

Ctenacanthus gracillimus Newberry and Worthen, p. 261.

7. Fin-spines, natural size.
Mississippian (St. Louis limestone); St. Louis, Missouri.

Psammodus plenis St. John and Worthen, p. 258.

8. A large-sized dental plate, natural size.
Mississippian (St. Louis limestone); near St. Louis, Missouri.

PLATE 8.

Polyrhizodus grandis, new species, p. 257.

FIGS. 1, 2. Dental plates, natural size.
Mississippian (St. Louis limestone); near Alton, Illinois.

Deltodus occidentalis (Leidy), p. 260.

FIG. 3. Dental plate, natural size.
Mississippian (St. Louis limestone); near St. Louis, Missouri.

Polyrhizodus concavus (St. John and Worthen), p. 257.

4. Dental plate, natural size.
Mississippain (St. Louis limestone); near St. Louis, Missouri.

Dipterus angustus (Newberry), p. 247.

5. Impression of dental plate, natural size.
Devonian (Chemung); Bradford County, Pennsylvania.

Chomatodus-type of tooth, p. 257.

6. Associated with *Polyrhizodus grandis*. Natural size.
Mississippian (St. Louis limestone); (?) near St. Louis, Missouri.

Cladodus spinosus Newberry and Worthen, p. 254.

7. Tooth, natural size.

Dinichthys pustulosus Eastman, p. 248.

8. Posterior process of dorsomedian plate, natural size.
Upper Devonian; Johnson County, Iowa.

PLATE 9.

Elonichthys perpennatus Eastman, p. 275.

FIG. 1. An incomplete example, natural size.
Pennsylvanian; Mazon Creek, Illinois.

Cheirodus orbicularis (Newberry and Worthen), p. 276.

2. A fairly well-preserved specimen, natural size.
Pennsylvanian; Mazon Creek, Illinois.

Elonichthys hypsilepis Hay, p. 274.

3. A nearly complete specimen, $\times\frac{1}{2}$.
Pennsylvanian; Mazon Creek, Illinois.

Rhadinichthys gracilis (Newberry and Worthen), p. 274.

4. A well preserved small specimen, $\times\frac{1}{2}$.
Pennsylvanian; Mazon Creek, Illinois.

Coelacanthus elegans (?) Newberry, p. 271.

FIGS. 5, 6. Two distorted incomplete skeletons, $\times\frac{1}{2}$.
Pennsylvanian; Mazon Creek, Illinois.

PLATE 10.

Coelacanthus exiguus Eastman, p. 271.

FIG. 1. A well-preserved example, $\times\frac{1}{2}$.
Pennsylvanian; Mazon Creek, Illinois.

Palaeophichthys parvulus Eastman, p. 272.

2. A specimen with the structural details impaired by oxidation, ×½.
Pennsylvanian; Mazon Creek, Illinois.

Elonichthys hypsilepis Hay, p. 274.

3. Skeleton in nodule showing fin structure, natural size.
Pennsylvanian; Mazon Creek, Illinois.

Cladodus aculeatus, new species, p. 255.

4. A tooth, ×½.
Mississippian (Caney shale); Antlers Quadrangle, Oklahoma.

Arthrodiran antero-ventro-lateral plate, p. 255.

FIGS. 5, 6. Two plates preserved in concretions, ×½.
Mississippian (Caney shale); Oklahoma.

Series of naturally associated Lepidotid scales, p. 279.

FIG. 7. Specimen, ×½.
Triassic, Kanab Canyon, Arizona.

PLATE 11.

Ceraspis carinata Schlüter, p. 242.

FIG. 1. Dorsomedian plate, side-view, natural size.

Middle Devonian; Eifel, Germany. Original in Museum of Comparative Zoology, Cambridge, Mass.

Ischyrhiza mira Leidy, p. 298.

2. Tooth, natural size. Cretaceous; near Dumas, Mississippe.

Coelacanthus elegans Newberry, p. 271.

FIGS. 3, 4. Two distorted examples, ×½.
Pennsylvanian; Mazon Creek, Illinois.

PLATE 12.

Catopterus gracilis Redfield, p. 280.

FIG. 1. Part of skeleton, including head with scales in place, ×½.

2. A crushed example, ×½.
Triassic; Durham, Connecticut.

Semionotus micropterus Newberry, p. 278.

3. Nearly complete specimen, ×½.
Triassic; Guilford, Connecticut.

Lepidotus walcotti, new species, p. 283.

4. Patch of scale impressions, ×½.
Triassic portion of Shinarump group; Kanab Valley section, Utah.

Astraspis desiderata Walcott, p. 238.

FIGS. 5, 6. Natural impression of body shield and plaster cast from same, ×½.
Ordovician (Harding sandstone of Black River); Canon City, Colorado.

PLATE 13.

Catopterus gracilis Redfield, p. 280.

FIG. 1. Fish on slab of shale, ×⅔.
Triassic; Guilford, Connecticut.

2. An incomplete specimen, ×⅔.
Triassic; Durham, Connecticut.

Lepidotus walcotti, new species, p. 283.

3. An incomplete individual, ×⅔.
Triassic portion of Shinarump group; Kanab Valley section, Utah.

PLATE 14.

Acanthurus, species indeterminate p. 290.

FIG. 1. Skeleton of young example, ×⅔.
Upper Eocene; Monte Bolca, Italy. Original in Museum of Comparative Zoology, Cambridge, Mass.

Belonostomus tenuirostris (Agassiz), p. 286.

2. Young individual, ×⅔.
Lithographic limestone, Solenhofen, Bavaria.

Belonorhynchus (?) species, p. 281.

3. Specimen, ×⅔.
Upper Triassic; New South Wales.

Notagogus minutus, new species, p. 287.

4. A complete skeleton on slab, ×⅔.
Lithographic limestone; Solenhofen, Bavaria.

PLATE 15.

Plioplarchus sexspinosus Cope, p. 295.

FIG. 1. Complete skeleton on slab, ×⅔.
Tertiary (Miocene);
Top of Sentinel Butte, North Dakota.

Notogoneus osculus Cope, p. 289.

2. Skeleton of young individual, ×⅔.
Eocene (Green River); Wyoming.

Semionotus elegans Newberry, p. 278.

3. A complete skeleton on slab of sandstone, ×⅔.
Triassic; Boonton, New Jersey.

PLATE 16.

Dapedoglossus testis Cope, p. 288.

FIG. 1. Well-preserved cranium, ×⅔.
Eocene (Green River); Wyoming.

Parafundulus nevadensis, new species, p. 291.

2. Nearly complete individual, in white clay matrix, ×⅔.
Tertiary (Lahonton beds); near Hazen, Nevada.

Xiphias? species, p. 298.

3. Hypural fan, natural size.
Tertiary (Eocene beds); Coosa River, South Carolina.

PLATE 17.

Parafundulus nevadensis, new species, p. 291.

A group of specimens, natural size.
Tertiary (Lahonton beds); near Hazen, Nevada.

PLATE 18.

Cladodus aculeatus, new species, p. 255.

FIG. 1. Teeth.
Mississippian (Caney); Antlers Quadrangle, Oklahoma.

Psephodus legrandensis Branson, p. 259.

2. Naturally associated dental plates of holotype.
Mississippian Kinderhook; Le Grand, Iowa.

Parafundulus nevadensis, new species, p. 291.

3. Drawing of skeleton figured in plate 16, figure 2.
Tertiary (Lahonton beds); near Hazen, Nevada.

Leuciscus (cf. *L. turneri*), p. 292.

4. Skeleton, natural size.
Oligocene or Lower Miocene; Madison Valley, Montana.

Osmerus (?) species, p. 293.

5. Skeleton.
Oligocene or Lower Miocene; Madison Valley, Montana.

PLATE 19.

Amyzon brevipinne Cope, p. 292.

FIG. 1. Nearly complete skeleton, $\times\frac{1}{2}$.
2. Skeleton lacking head portion, $\times\frac{2}{3}$.
Tertiary (Lower Miocene); near Republic, Washington.

Cyprinodont, p. 293.

3. Example of an undetermined species, $\times\frac{1}{2}$.
Tertiary; Mexico.

PLATE 20.

Ameiurus primaevus, new species, p. 293.

Nearly complete skeleton of holotype, $\times\frac{1}{2}$.
Eocene (Green River); Wyoming.

PLATE 21.

Mioplosus labracoides Cope, p. 295.

A large well-preserved specimen, $\times\frac{1}{2}$.
Eocene (Green River); Wyoming.

PLATE 22.

Plioplarchus septemspinosus Cope, p. 295.

One of the type-specimens, ×½.
Miocene (?); Van Horn's Ranch, on the John Day River, Oregon.

PLATE 23.

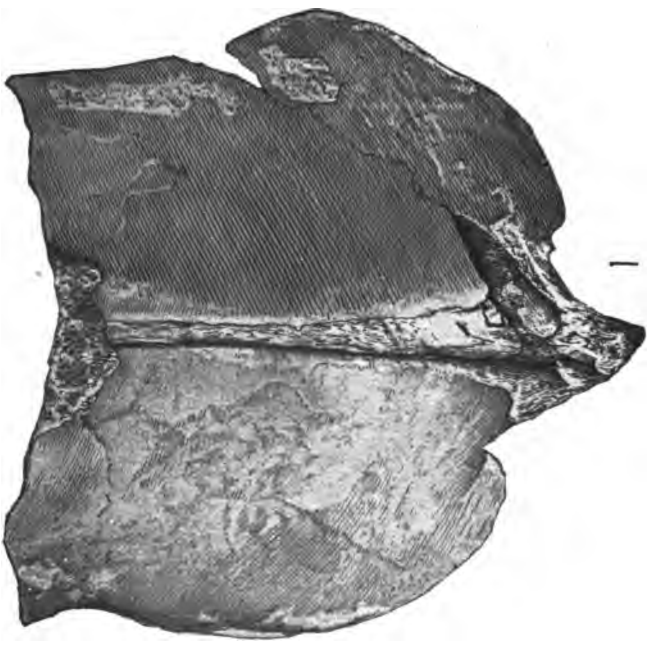
Priscacara dartonae, new species, p. 296.

Complete skeleton of the holotype, ×½.
Eocene (Green River); near Fossil, Wyoming.

HETERACANTHUS UDDENI.

FOR EXPLANATION OF PLATE SEE PAGE 298.

2



1

DINICHTHYS TUBERCULATUS AND SAURIPTERUS TAYLORI.

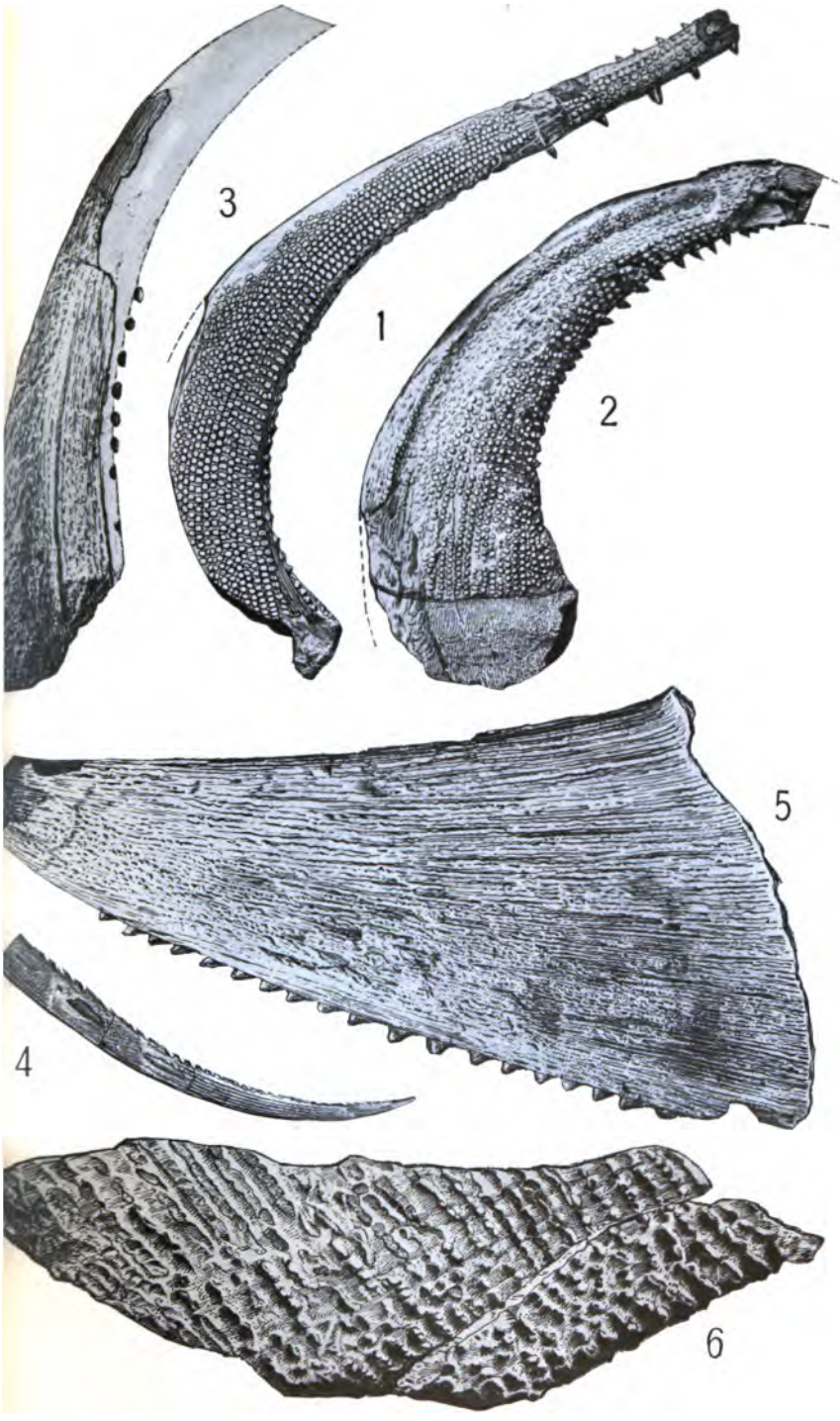
FOR EXPLANATION OF PLATE SEE PAGE 298.

PHYSONEMUS GEMMATUS.

FOR EXPLANATION OF PLATE SEE PAGE 298.

PHYSONEMUS GEMMATUS.

FOR EXPLANATION OF PLATE SEE PAGE 298.

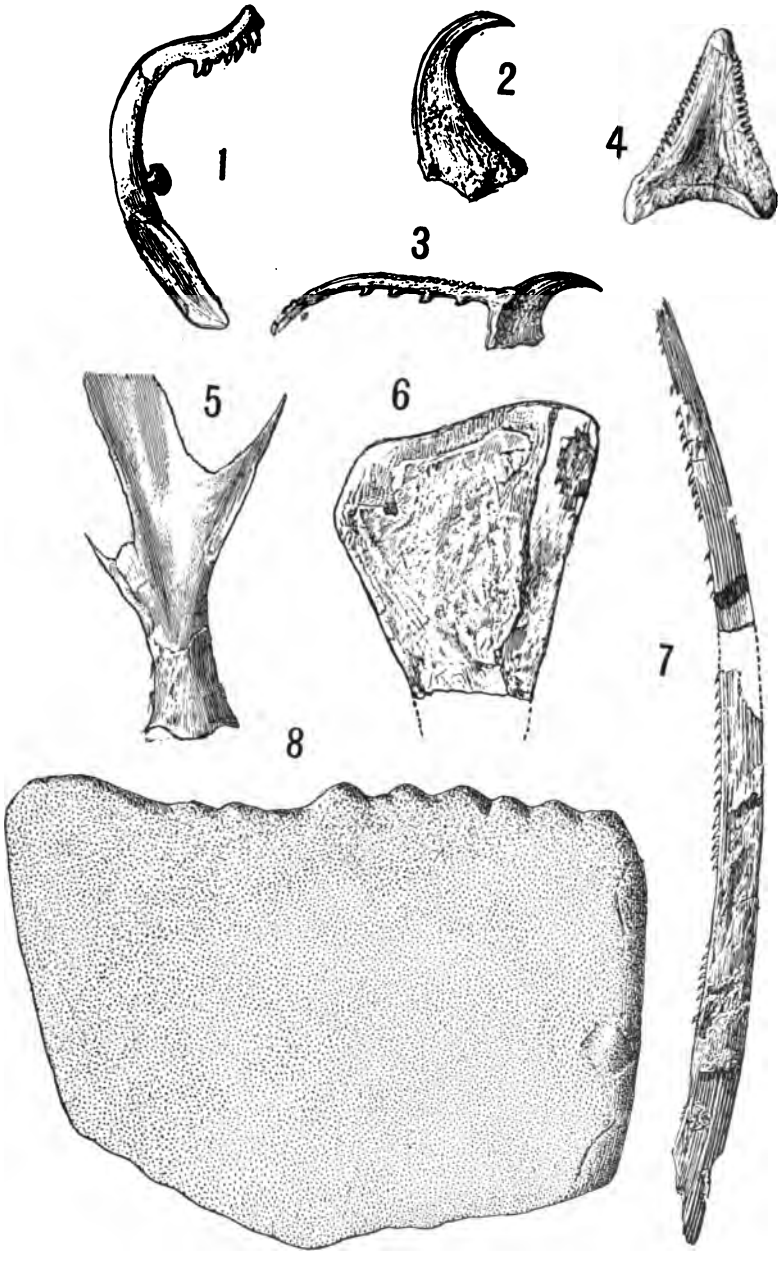


PHYSONEMUS ARCUATUS, P. GEMMATUS, CTENACANTHUS GRACILLIMUS, AND ORACANTHUS TRIANGULARIS.

FOR EXPLANATION OF PLATE SEE PAGES 298 AND 299.

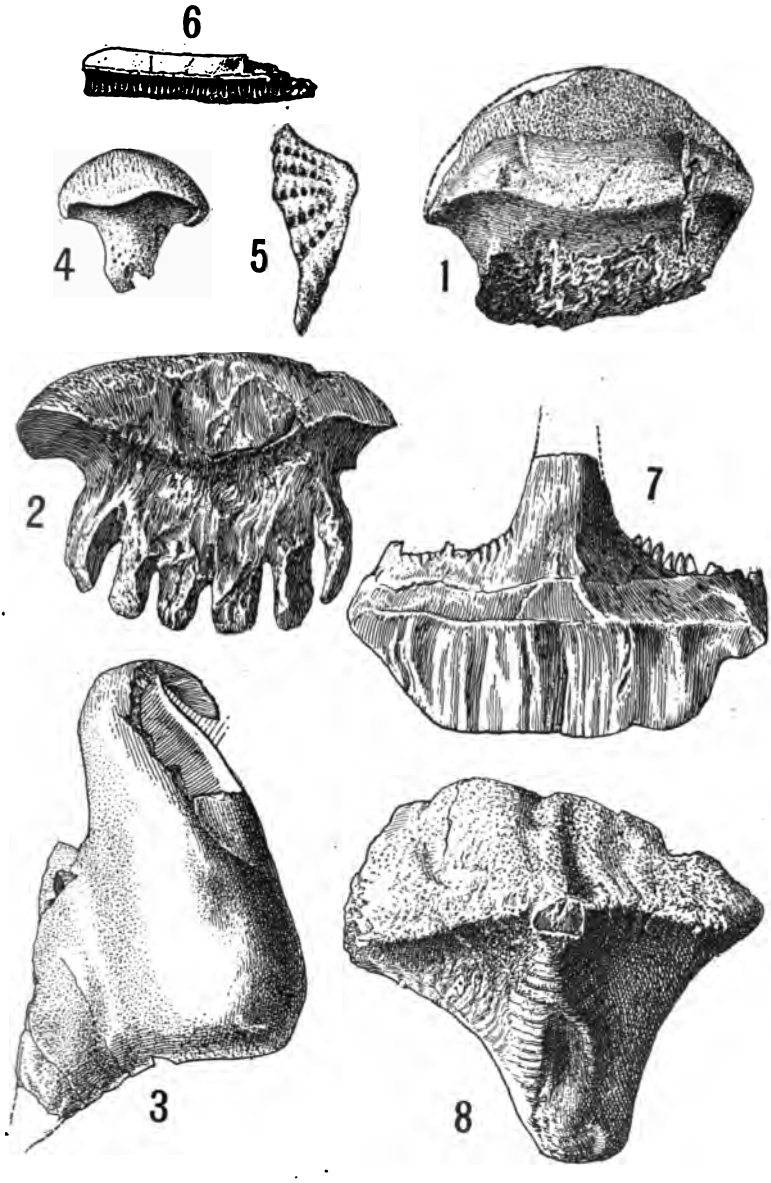
EDESTUS HEINRICHI AND ORACANTHUS VETUSTUS.

FOR EXPLANATION OF PLATE SEE PAGE 299.



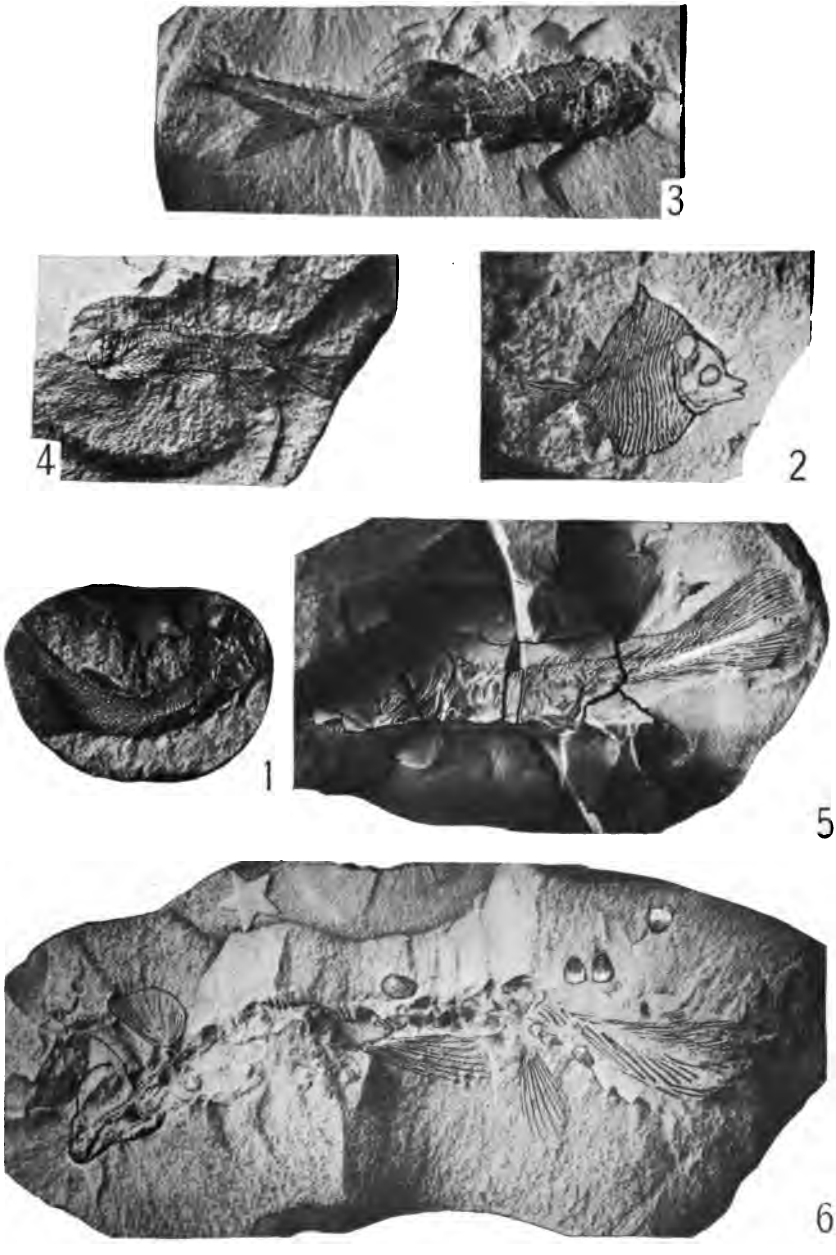
HARPACANTHUS PROCUMBENS, ERISMACANTHUS MACCOYANUS, DICRENODUS TEXANUS, SAURIPTERUS TAYLORI, COCCOSTEUS, SPECIES, CTENACANTHUS GRACILLIMUS, AND PSAMMODUS PLENIS.

FOR EXPLANATION OF PLATE SEE PAGE 299.



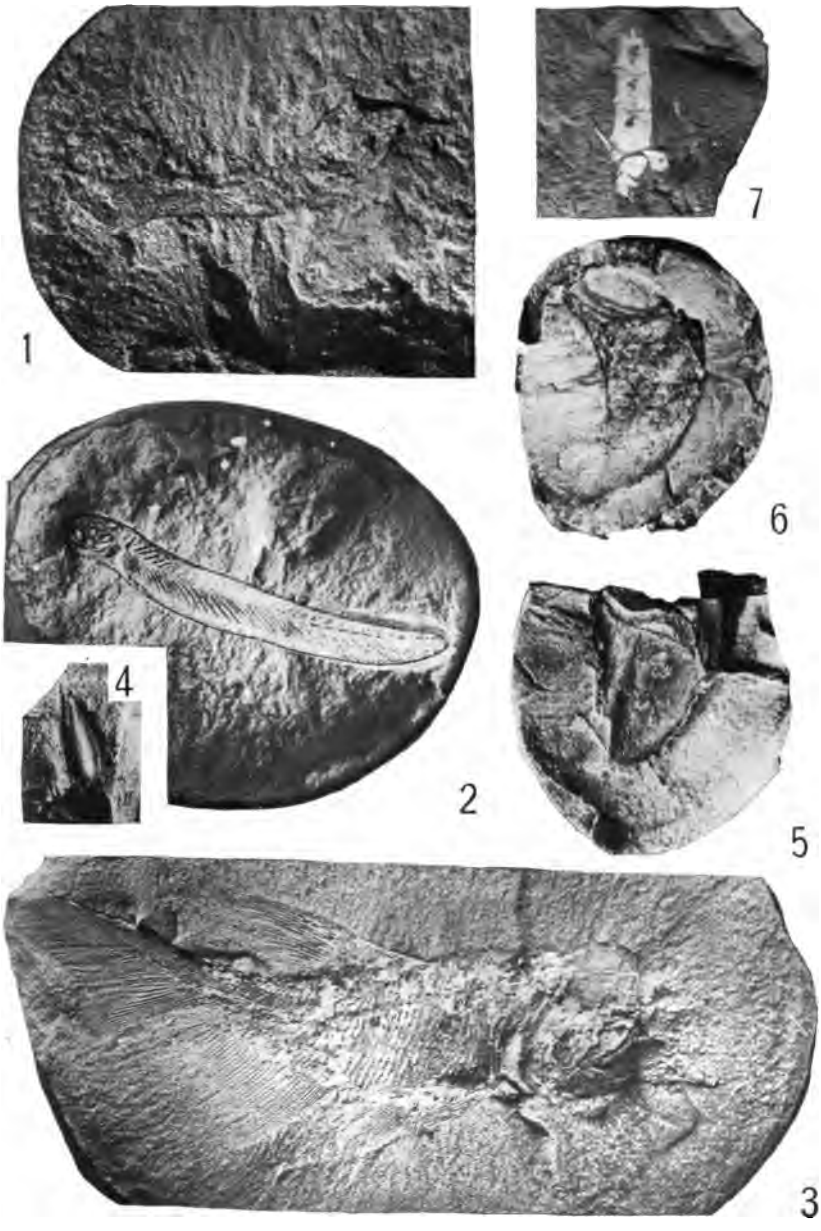
POLYRHIZODUS GRANDIS, DELTODUS OCCIDENTALIS, POLYRHIZODUS CONCAVUS, DIPTERUS ANGUSTUS, POLYRHIZODUS GRANDIS, CHOMATODUS, SPECIES, CLADODUS SPINOSUS, AND DINICHTHYS PUSTULOSUS.

FOR EXPLANATION OF PLATE SEE PAGES 299 AND 300.



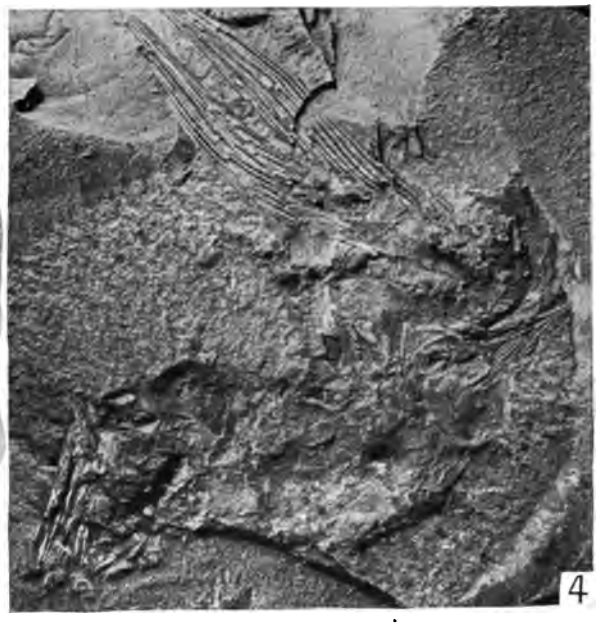
ELONICHTHYS PERPENNATUS, CHEIRODUS ORBICULARIS, ELONICHTHYS HYPSIPLEPIS, RHADINICHTHYS GRACILIS, AND COELACANTHUS ELEGANS.

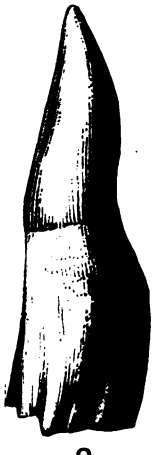
FOR EXPLANATION OF PLATE SEE PAGE 300.



COELACANTHUS EXIGUUS, PALAEOPHICHTHYS PARVULUS, ELONICHTHYS HYPSILEPIS, CLADODUS ACULEATUS, ARTHRODIRAN PLATES, AND LEPIDOTID SCALES.

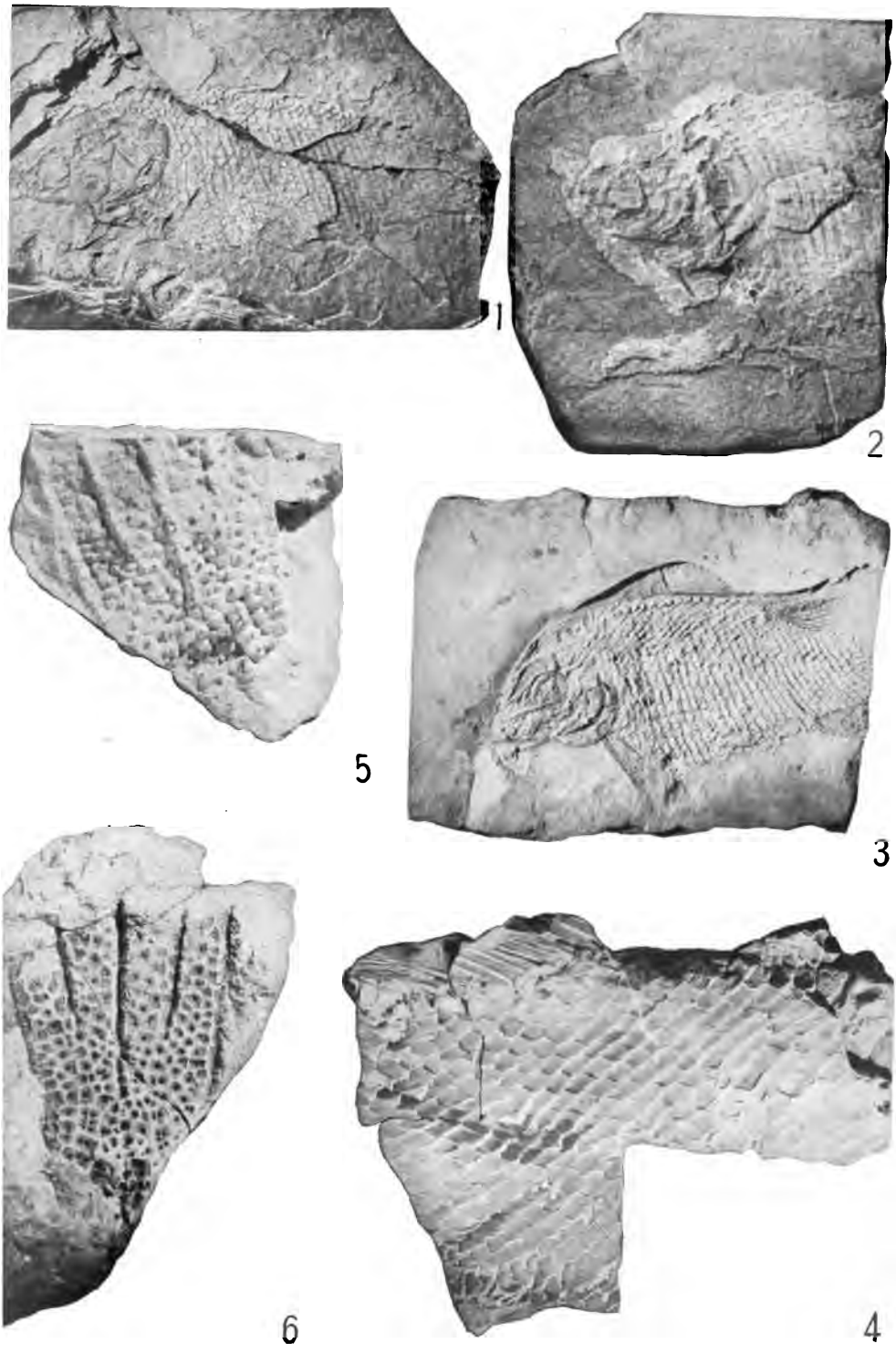
FOR EXPLANATION OF PLATE SEE PAGES 300 AND 301.





CERASPIS CARINATA, ISCHYRIZA MIRA, AND COELACANTHUS ELEGANS.

FOR EXPLANATION OF PLATE SEE PAGE 301.

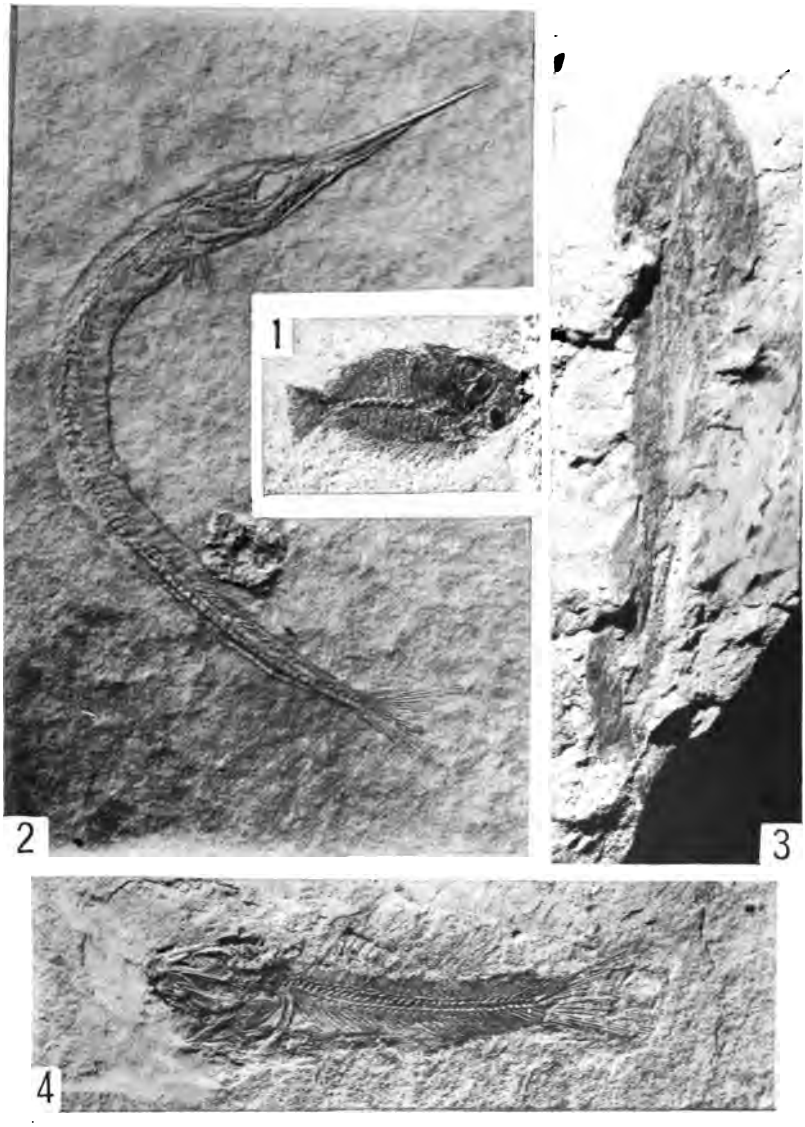


CATOPTERUS GRACILIS, SEMIONOTUS MICROPTERUS, LEPIDOTUS WALCOTTI, AND ASTRASPIS DESIDERATA.

FOR EXPLANATION OF PLATE SEE PAGE 301.

CATOPTERUS GRACILIS, AND LEPIDOTUS WALCOTTI.

FOR EXPLANATION OF PLATE SEE PAGE 302.

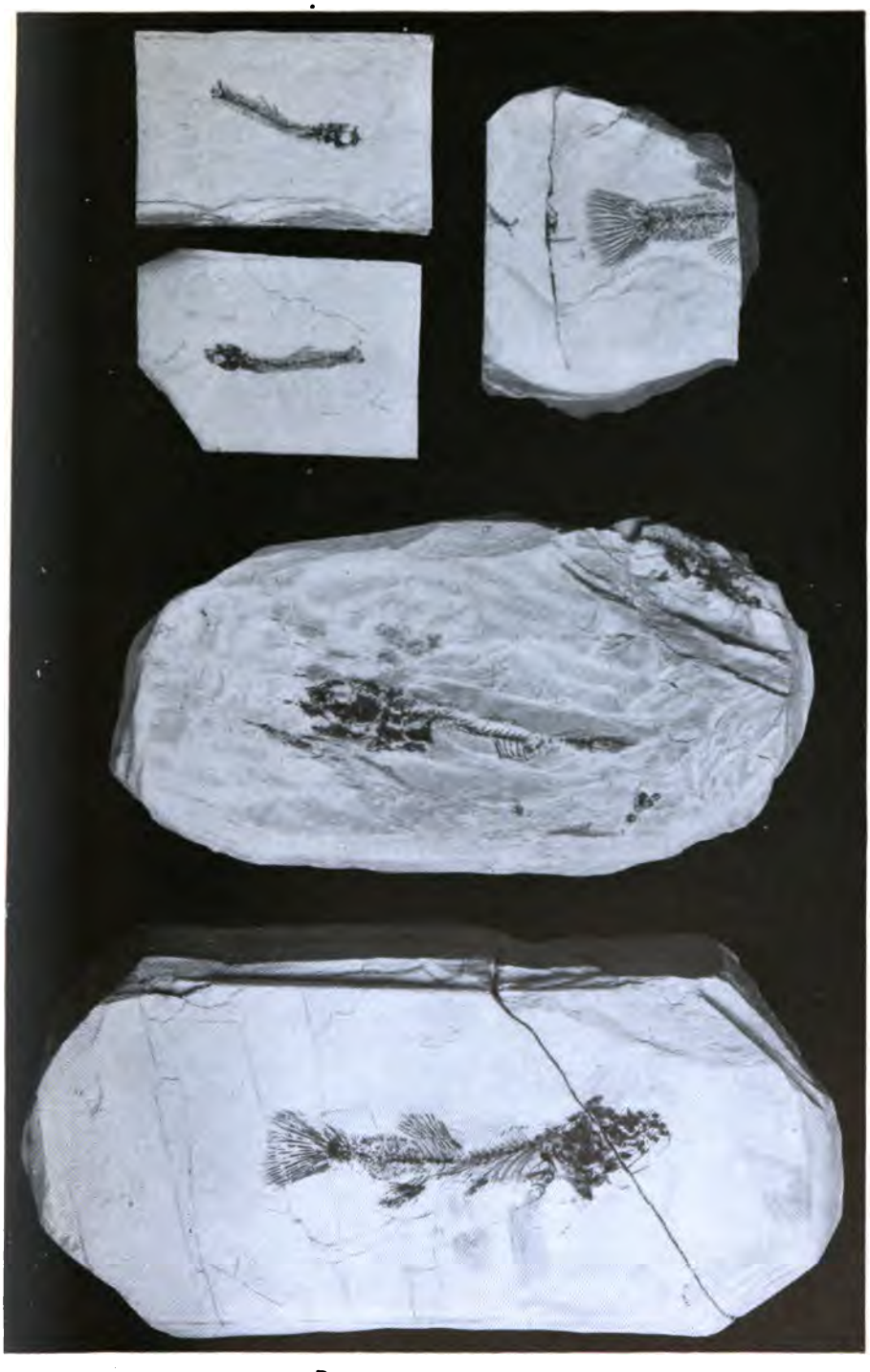


ACANTHURUS, SPECIES, BELONOSTOMUS TENUIROSTRIS, BELONORHYNCHUS (?) SPECIES, AND NOTAGOGUS MINUTUS.

FOR EXPLANATION OF PLATE SEE PAGE 302.

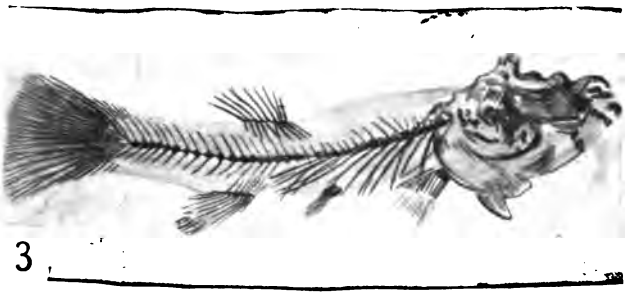
DAPEDOGLOSSUS TESTIS, PARAFUNDULUS NEVADENSIS, AND XIPHIAS?, SPECIES.

FOR EXPLANATION OF PLATE SEE PAGES 302 AND 303.



PARAFUNDULUS NEVADENSIS.

FOR EXPLANATION OF PLATE SEE PAGE 303.



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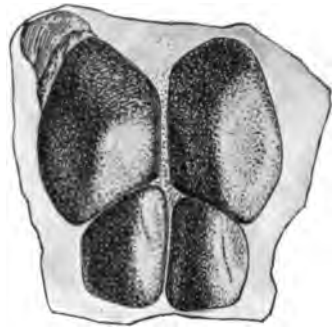

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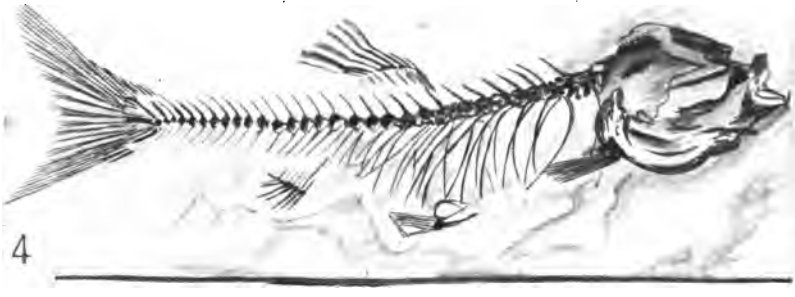

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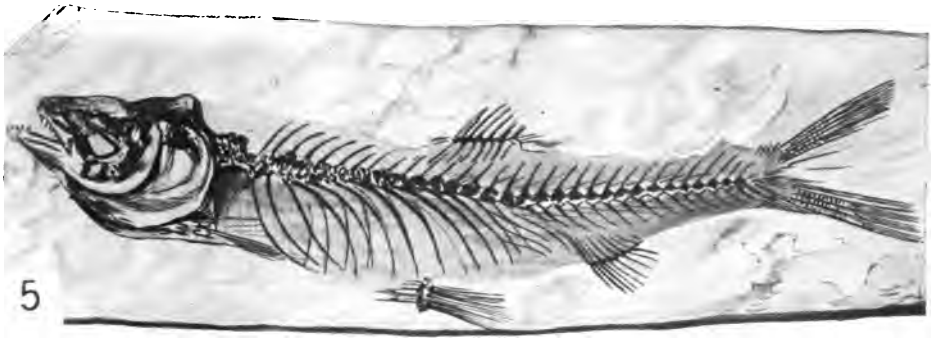
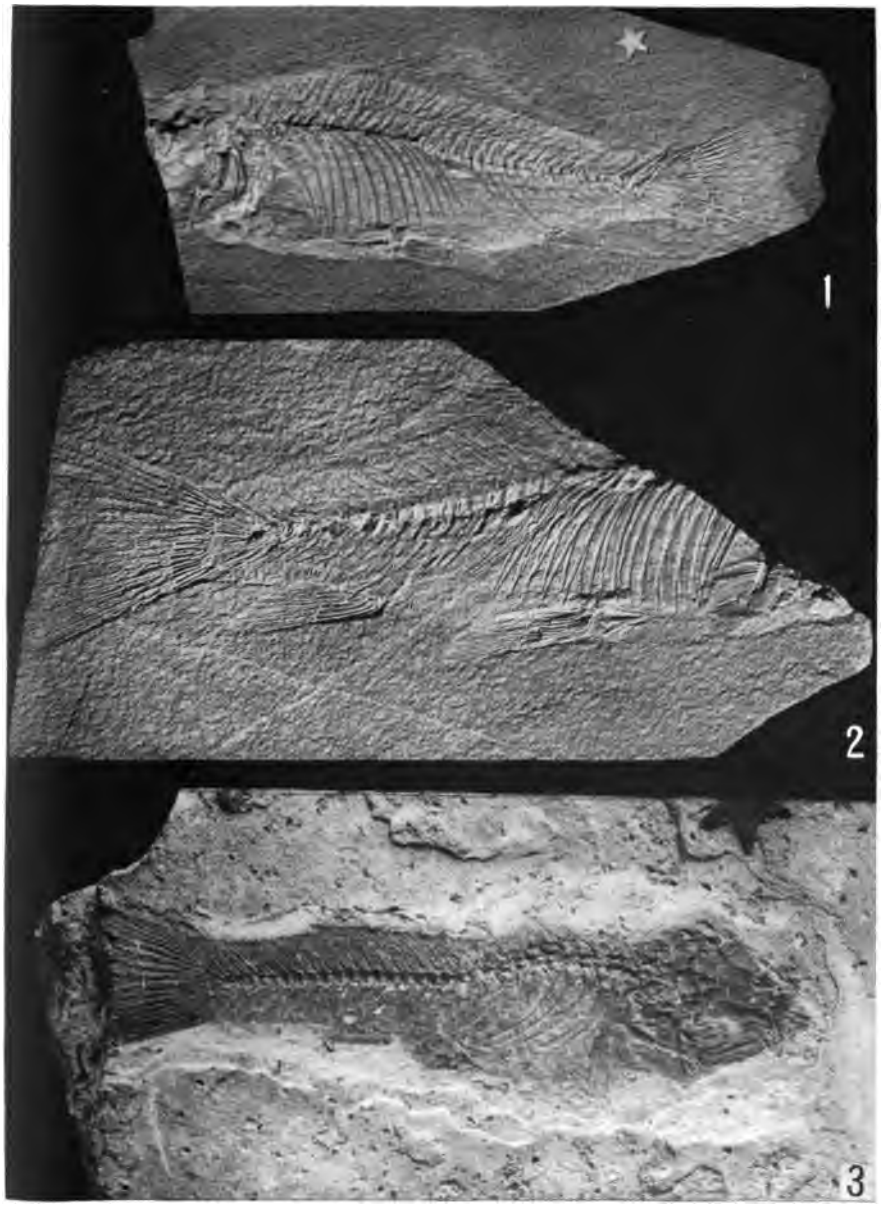


5

CLADODUS ACULEATUS, PSEPHODUS LEGRANDENSIS, PARAFUNDULUS NEVADENSIS, LEUCISCUS, AND OSMERUS (?) SPECIES.

FOR EXPLANATION OF PLATE SEE PAGE 303.



AMYZON BREVIPINNE, AND CYPRINODONT.

FOR EXPLANATION OF PLATE SEE PAGE 303.

AMEIURUS PRIMAEVUS.

FOR EXPLANATION OF PLATE SEE PAGE 303.

MIOPLOSUS LABRACOIDES.

FOR EXPLANATION OF PLATE SEE PAGE 303.

PLIOPLARCHUS SEPTEMSPINOSUS.

FOR EXPLANATION OF PLATE SEE PAGE 304.

PRISCACARA DARTONAE.

FOR EXPLANATION OF PLATE SEE PAGE 304.

Eastman

1917

Dentition of Hydrocyon and its supposed fossil Allies.

By Charles R. Eastman.

BULLETIN OF THE

AMERICAN MUSEUM OF NATURAL HISTORY.

Vol. XXXVII, Art. XXVI, pp. 757–760.

New York, November 26, 1917.

(*Continued from 3d page of cover.*)

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Ethnographical Album of the North Pacific Coasts of America and Asia. Part 1, pp. 1–5, pll. 1–28. August, 1900. Sold by subscription, price, $6.00.

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*The Anatomy of the Common squid. By Leonard Worcester Williams. Pp. 1–87, pll. i–iii, and 16 text figures. 1909.

*Chinese Pottery of the Han Dynasty. By Berthold Laufer. Pp. 1–339, pl. i–lxxv, and 55 text figures. 1909.

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Article XXVI.—DENTITION OF *HYDROCYON* AND ITS SUPPOSED FOSSIL ALLIES.[1]

By Charles R. Eastman.

Plates LXXXIV–LXXXVII.

Among the interesting specimens of African fishes brought back by Mr. Herbert Lang, leader of the Belgian Congo Expedition, is one of an adult *Hydrocyon lineatus*, the skull and skeleton of which have been prepared for study. An examination of the dentition shows that this form presents novel features, not heretofore observed among teleosts.

The powerful cutting teeth are not implanted in sockets, nor coössified with the bony elements of upper and lower jaws, but are attached to these elements by ligamentous union, closely paralleling the mode of attachment of teeth to the supporting cartilage in the jaws of sharks. Associated with this peculiar modification is another and still more noteworthy parallelism with dental conditions found in elasmobranchs, namely, as regards replacement of teeth. As functional teeth become effete with use and fall out, or are crowded over on the exterior margin of the jaws, above and below, they are replaced by a series of successional teeth which are formed in separate pouches on the inner face of the premaxillary and dentary bones, and gradually work their way into position so as to stand upright along the functional margin of the jaw bones. Whereas several rows of successional teeth are developed in cartilaginous fishes, apparently not more than two series are present in *Hydrocyon*, the set which is functional at a given time, and another in process of formation. Appearances indicate that tooth formation here, as in elasmobranchs, is a continuous process.

One other remarkable modification remains to be noted. There is no rigid union of the premaxillary and dentary bones at the symphysis, but instead the anterior extremities of both pairs are movably articulated with each other, there being several perfectly formed hinge-like joints in vertical alignment at the symphysis in both jaws, the whole constituting a neat interlocking contrivance for permitting motion and allowing for a lateral expansion of the mouth-angles in the quadrate region. The device is comparable to the hinged dentary bone of mosasaurs, and, so far as known to the writer, does not occur elsewhere than in *Hydrocyon* and one other Characin among fishes. The second known instance where this hinge-like arrangement is developed, is in the South American genus *Hoplias*, as pointed out to the writer by his friend Mr. J. T. Nichols. A lower jaw of *Hoplias* from Colombia, in

[1] Scientific Results of the American Museum of Natural History Congo Expedition. Ichthyology, No. 2.

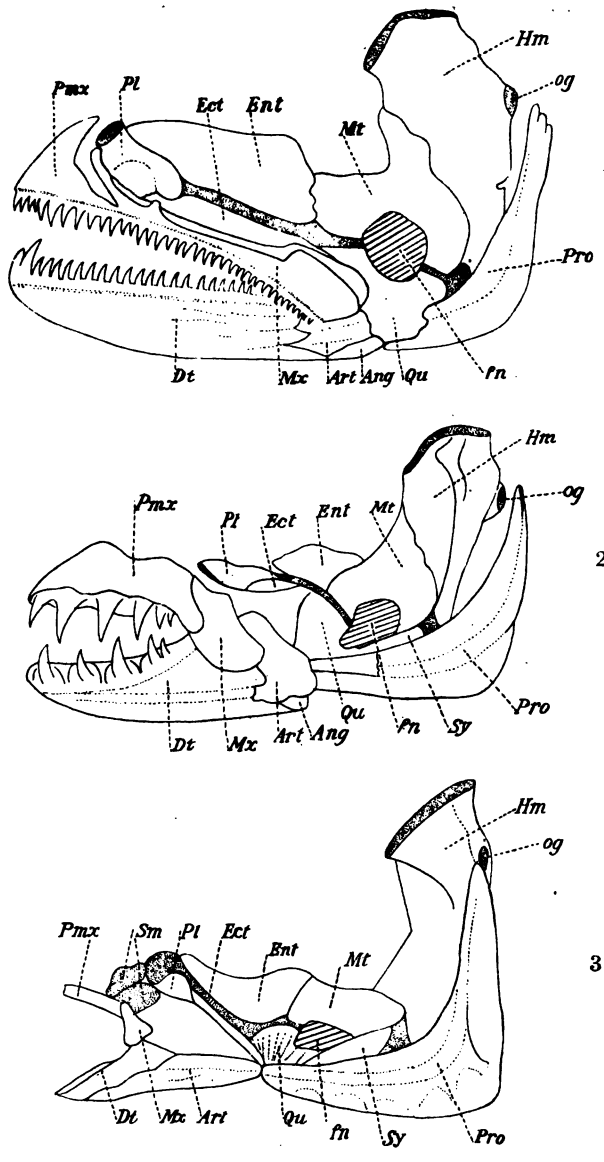

Fig. 1. Suspensorial and mandibular apparatus of *Erythrinus*. 1½. *Ang.*, angular; *Art.*, articular; *Dt.*, dentary; *Ect.*, ectopterygoid; *Ent.*, entopterygoid; *fn.*, vacuity between the metapterygoid, symplectic and quadrate; *Hm.*, hyomandibular; *Mt.*, metapterygoid; *Mx.*, maxilla; *og.*, articular surface for the operculum; *Pl.*, palatine; *Pmx.*, premaxilla; *Pro.*, præoperculum; *Qu.*, quadrate.

Fig. 2. Suspensorial and mandibular apparatus of *Hydrocyon forskalii*. ½. Notations same as for Fig. 1. *Sy.*, symplectic.

Fig. 3. Suspensorial and mandibular apparatus of *Citharinus*. ½. Notations same as for Fig. 1. *Sm.*, submaxillary cartilage.

which this character is distinctly shown, has recently been presented to the American Museum by Mr. Leo E. Miller, who collected it.

The articulations observed in a few specimens of *Coccosteus* along the front margin of the jaws appear to have been in the nature of teeth, and to have subserved a different function than that here noted for *Hydrocyon* and *Hoplias*.

An excellent description of the structure of the skull in Characins is given by M. Sagemehl in the 'Morphologisches Jahrbuch' for 1885 (Vol. 10, pp. 1–119). The article is accompanied by illustrations, reproduced in Text Figs. 1–3, which show the formation of the mouth-parts in two genera of carnivorous and one of herbivorous Characins. The latter type, such as is presented by *Citharinus* (Text Fig. 3) recalls conditions found in *Amia*, and is regarded as "weit primitiver" than the type of jaw-structure found in *Hydrocyon* and *Erythrinus*. Nothing is said by the author regarding the mode of replacement of the teeth or of the movable articulation at the symphysis in *Hydrocyon*.

Fossil predecessors of Characins have not been hitherto identified with certainty, and accordingly any information regarding the geological history of the group is to be welcomed. Now it is an interesting fact that in searching fossil records for a type of tooth-structure similar to that represented by *Hydrocyon*, a very close approximation is found in the species of detached teeth from late Cretaceous and early Tertiary strata which have been described under the names of *Onchosaurus*, *Ischyrhiza* and *Gigantichthys*.[1]

All of these forms, like *Hydrocyon*, have elongated, acuminate crowns with slightly compressed, trenchant edges, and covered with a thin layer of enamel. The root is vertical, abruptly truncated below and hollowed interiorly, with coarse crenulations on the outer surface near the base. Examining the root from below, the basal portion is seen to be deeply excavated along the median line by a longitudinal groove. The characters last described evidently provide means for securing a firm attachment of the teeth to the supporting tissue of the jaws, since the teeth are not implanted in alveoli. In all of these respects, there is remarkably close agreement between the above-named fossil teeth and those of the recent genus *Hydrocyon*. The conclusion appears inevitable that all these forms are related, and that the ancestry of modern Characins may be traced back to *Onchosaurus* of the Cretaceous. One of the fossil species, *O. pharao* (Dames) is found in the Upper Cretaceous of Africa, and other representatives occur in Europe and North America. The type of *O. mira* (Leidy), now preserved in the American Museum of Natural History, is shown in Plate LXXXVI, B–C.

[1] For a discussion of the synonymy and probable relationships of these forms, see an article by the present writer in the 'American Naturalist' for 1904, Vol. 38, p. 298.

EXPLANATION OF PLATES LXXXIV–LXXXVII.

Plate LXXXIV.

Lower jaw of *Hydrocyon lineatus* to show the peculiar interlocking hinge-joint at the symphysis.

A. View from above of dentaries spread apart to greatest extent. ½.

B. Same view; dentaries approximated as closely as possible. ½.

C. Posterior view of the hinge when fully opened. ¾. Although the dentaries can be freely moved, they cannot be separated without injury as in *Hoplias*. The successional teeth may be seen, lying in the alveolar pits with the points directed backward, so that a rotation is necessary to bring them in functional position. Note the peculiar form of attachment of the teeth suggesting *Onchosaurus mira* (Plate LXXXVI, Figs. *B* and *C*).

Plate LXXXV.

Ventral view of anterior portion of skull of *Hydrocyon lineatus* with the tooth bearing premaxillæ and the hinged symphysis. ½. The mesethmoid is expanded laterally to furnish an articular surface for the necessary movements of the premaxillæ. The successional teeth are clearly shown in their alveolar pits.

Plate LXXXVI.

Two distal teeth (*A*) of right dentary of *Hydrocyon lineatus* compared with front (*B*) and side (*C*) views of tooth (type specimen No. 10452, A. M. N. H.) of *Onchosaurus mira* (Leidy) from the Cretaceous of New Jersey. (Natural size.) Note the remarkable similarity in general form, especially near the base, that suggests the same mode of attachment.

Right lower jaw (*D*) of *Hoplias* (a South American Characin) viewed from inside (⅔), and outer view of the largest anterior tooth (*E*). (⅘). As in *Hydrocyon* and *Onchosaurus*, all these large teeth are slightly hollow inside and are fastened to the dentary by only ligamentous connection. The gum-covered, basal, ridged portion is completely free from enamel and in this feature and its strongly trenchant edges, *Hoplias* resembles even more the Cretaceous form, whereas in *Hydrocyon* the enamel often reaches nearly to the base of the teeth.

The hollow rear portions of some of the successional teeth are seen in their natural position near the front of the jaw; they become functional without rotation.

One side of the large interlocking hinge at the mandibular symphysis is clearly shown and resembles much in form and in function that of *Hydrocyon*.

Plate LXXXVII.

Head of *Hydrocyon lineatus* (*A*) to illustrate the interlocking of the teeth when the mouth is closed. It is interesting to note that about half of the entire length of the teeth is embedded in the gum. The wide-open mouth of this specimen is figured in Plate LXX, Fig. 1. Photo by H. Lang from a freshly captured specimen (total length 61 cm.), Faradje, Uele District, Belgian Congo.

Left premaxilla of *Hydrocyon lineatus* (*B*), viewed from inside (¾), showing the one and only series of reserve teeth. These are obliged to rotate into functional position like those of sharks and are attached to the jaw by simple ligamentous connection, without sockets or coössification.

Lower jaw of *Hydrocyon lineatus* to show the peculiar interlocking hinge-joint at the symphysis.

A, dentaries spread apart fully; *B*, closely approximated ($\frac{1}{2}$); *C*, posterior view of the hinge ($\frac{2}{3}$).

Ventral view of anterior portion of skull of *Hydrocyon lineatus* with the tooth-bearing premaxillæ and the hinged symphysis. $\frac{1}{1}$.

A

B

C

D

E

Two distal teeth (*A*) of right dentary of *Hydrocyon lineatus* compared with front (*B*) and side (*C*) views of a tooth of *Onchosaurus mira* (Leidy). $\frac{1}{1}$. Right lower jaw (*D*) of *Hoplias* ($\frac{3}{2}$), viewed from inside, and outer view of the largest anterior tooth (*E*). $\frac{4}{1}$.

A

B

Head of *Hydrocyon lineatus*. *A*, to illustrate the interlocking of the teeth when the mouth is closed; *B*, left premaxilla of *Hydrocyon lineatus*, viewed from inside ($\frac{3}{4}$), showing the full series of reserve teeth.

(*Continued from 4th page of cover.*)

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(*Continued on 2d page of cover.*)

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CHARLES ROCHESTER EASTMAN[1]

ON this side of the Atlantic there have been few zoologists who have devoted their lives to the study of ancient fishes—which for the rest concerns not a few of the greatest problems of the vertebrates. Of investigators who have passed away we recall the distinguished names of Agassiz the elder, Cope, Newberry and Leidy, and to this goodly fellowship we must now add the name of Charles Rochester Eastman, whose services have contributed widely and intensively to a knowledge of fossil fishes. To this work he gave his time devotedly for a quarter of a century, publishing over a hundred papers, among them a number of monographs which rank among the most scholarly and accurate in their field.

Eastman graduated from Harvard in 1891, studied at Johns Hopkins, thereafter in the University of Munich, where he took his doctorate in 1894; he worked with Professor Karl von Zittel, whose laboratory then attracted a number of young American paleontologists. Here, as Eastman's interests already centered in fossil fishes, he was given the only material for research which the German university had at hand—a mass of detached teeth of a Chalk Measures shark—not attractive material, to say the least, but the young investigator attacked it with energy and soon gathered the data for a successful thesis. He was next given a post at Harvard, where in the Museum of Comparative Zoology, under the mantle of Louis Agassiz, he reviewed the collections of early fishes and found much material for publication. He now became interested in the Devonian fossils of the Agassiz collection, which he found shed light upon the rich finds from the Middle West, then being described by Dr. Newberry. Eastman's imagination was especially touched by the range and character of "placoderms" as the dominant group of Devonian times, and like many another worker, he set himself to solve the puzzles of their lines of evolution and of their kinship to modern fishes. Hence

[1] Born Cedar Rapids, Iowa, June 5, 1868, died Long Beach, N. Y., September 27, 1918.

he sought actively for more extensive and better preserved material upon which to base his findings. The best collecting ground for these American forms was in Ohio, and throughout this region Eastman soon learned to know the fossil hunters and their collections. His studies upon these forms thereupon spread over wider fields, and became well-nigh encyclopædic; he brought the entire Devonian fish fauna under his finger tips, literally: and if Eastman were sought for at this time, he would have been found at the top of the Agassiz Museum in the center of a labyrinth made up of tiers of great trays of fossils: and the visitor would come away with the impression that there was something almost uncanny in the skill with which Eastman could call up out of the mud-colored shales these primæval creatures, for their *membra disjuncta* would be made to fit in place so quickly, so faultlessly, and sometimes with so audible a click that one could almost picture the fish coming to life in its tray.

From the study of placoderms, Eastman's studies extended naturally to the contemporary lung-fishes and ganoids, and to our knowledge of these early forms he made numerous contributions. Now and again he would hark back to the group of sharks, trying ever to bring order into this primitive and difficult group. Port Jackson sharks, with their curiously modified dentition, which enabled them to crush the shells of shellfish, suggested new lines of evolutional changes, and his work on these forms from Illinois, Iowa, Missouri, Kansas and Nebraska showed new sequences and enabled him to fill out the gaps in their history. Certain of these early sharks became so similar to lung-fishes in their dentition, that, on this evidence alone, the two great groups of fishes might readily have been merged.

During the last decade of his work, Eastman's attention was drawn more closely to types of modern fishes. This was perhaps due to the fact that he had been able to bring to this country the famous collection of a Belgian paleontologist, de Bayet, and install it in the Carnegie Museum at Pittsburgh. Upon the fishes of this collection, especially those from northern Italy (Monte Bolca) he published a number of beautiful memoirs.

In matters relating to the phylogeny of fishes, Eastman was conservative. Thus, following Smith Woodward, he maintained that the group of placoderms which the latter defined as *Arthrodira* was definitely related to primitive lung-fishes: he had little sympathy with those who believed that they had solved the riddle of *Trematapsis* and *Bothriolepis* by associating with them arthropods. As a systematist, Eastman was thorough, and the forms which he described will rarely need revision.[2]

[2] Mrs. H. J. Volker has recently reviewed the papers of Dr. Eastman, and summarizes his systematic contributions as follows:

New families: (3)
Astraspidæ.
Peripristidæ.
Pholidophoridæ.

New genera: (12)
Belemnacanthus.
Campyloprion.
Eobothus.
Eolabroides.
Gillidia.
Histionotophorus.
Palæophichthys.
Parafundulus.
Parathrissops.
Phlyctænacanthus.
Protitanichthys.
Tamiobatis.

New species: (115)
Acanthodes beecheri; marshi.
Ameiurus primævus.
Amiopsis* (?) *dartoni.
Anguilla branchiostegalis.
Asterolepis clarkei.
Asthenocormus retrodorsalis.
Belemnacanthus giganteus.
Blochius moorheadi.
Bothriolepis coloradensis.
Campyloprion annectans.
Caranx primævus.
Carcharias collata; incidens.
Cestracion zitteli.
Chanoides leptostea.
Cladodus aculeata; prototypus; urbs-ludovici.
Cœlacanthus exiguus; welleri.
Cœlogaster analis.
Conchodus variabilis.
Ctenacanthus acutus; decussatus; longinodosus; lucasi; solidus; venustus.
Dicrenodus texanus.
Dinichthys dolichocephalus; livonicus; pelmensis; pustulosus; trautscholdi.
Diplodus priscus; striatus.
Diplomystus goodi.
Dipterus calvini; costatus; digitatus; mordax; pectinatus; uddeni.
Elonichthys disjunctus; perpennatus.
Eomyrus formosissimus; interspinalis.
Erismacanthus barbatus; formosus.
Fissodus dentatus.
Galeocerdo triqueter.
Glyptaspis abbreviata.
Gyracanthus primævus.

No one can recall Dr. Eastman without bringing to mind his keen appreciation of ancient literature. He read the classical texts fluently, and Aristotle and Pliny had to him the interest of modern authors. Perhaps he knew them and their kindred better than did any living paleontologist. For bibliographical work Eastman had ever a distinct leaning, for to know what others had done in a definite field was the only honest beginning of any research. It was this interest which led him to accept the invitation of the American Museum of Natural History to undertake the editorship of a bibliography of fishes which the museum was engaged in publishing, and it was under his supervision that the two first volumes of this work appeared—ever to lighten the labors of workers in this field.

BASHFORD DEAN

Harpacanthus procumbens.
Helodus comptus; incisus.
Histionotus reclinis.
Homacanthus acinaciformis; delicatulus.
Homœolepis suborbiculata.
Janassa maxima; unguicula.
Lepidotus ovatus; walcotti.
Machæracanthus longævus.
Macrosemius dorsalis.
Mene novæ-hispaniæ.
Myliobatis frangens.
Mylostoma newberryi.
Notagogus decoratus; minutus; ornatus.
Œonoscopus elongatus.
Onchus rectus.
Oracanthus triangularis.
Orodus intermedius.
Palæophichthys parvulus.
Parafundulus nevadensis.
Parathrissops furcatus.
Phlyctænacanthus telleri.
Phœbodus dens-neptuni; knightianus.
Pholidophorus americanus.
Phyllodus hipparionyx.
Physonemus hamus-piscatorius; pandatus.
Platinx intermedius.
Polyrhizodus grandis.
Priscacara dartoni.
Propterus conidens.
Protitanichthys fossatus.
Ptyctodus compressus; ferox; panderi; predator; punctatus.
Pygæus agassizii.
Rhadinichthys deani.
Rhynchodus major; pertenuis; rostratus.
Sagenodus cristatus; pertenuis.
Sauropsis curtus; depressus.
Squatina minor; occidentalis.
Stethacanthus erectus.
Streblodus angustus.
Synechodus clarkii.
Synthetodus calvini.
Tamiobatis vetustus.
Undina grandis.
Urosphen attenuata.